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Inventor Information for 10/684151

Inventor Name	City	State/Country
SEGALL, PAUL E.	BERKELEY	CALIFORNIA
STERNBERG, HAL	BERKELEY	CALIFORNIA
WAITZ, HAROLD D.	BERKELEY	CALIFORNIA
SEGALL, JUDITH M.	BERKELEY	CALIFORNIA

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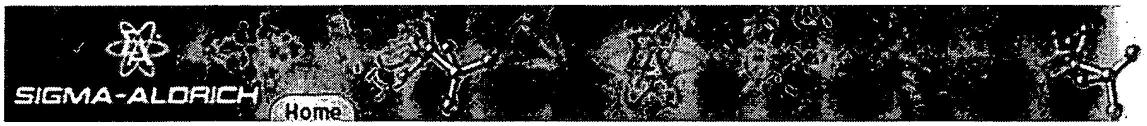

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Buffer Substances

Prod. No.	**Buffer** substances
93331	2,4,6-Tris(dimethylaminomethyl)phenol
40340	3,3-Dimethylglutaric acid
54466	4-(2-Hydroxyethyl)piperazine-1-ethane-sulf. acid Sod.salt*
54461	4-(2-Hydroxyethyl)piperazine-1-ethanesulfonic acid*
54465	4-(2-Hydroxyethyl)piperazine-1-propane-sulfonic acid*
54463	4-(2-Hydroxyethyl)piperazine-1-propanesulfonic acid*
04500	4-Ethylmorpholine
32002	5,5-Diethylbarbituric acid **Sodium** salt
31999	5,5-Diethylbarbituric acid **Sodium** salt*
39566	5,5-Dimethylbarbituric acid
06012	5-Allyl-5-isobutylbarbituric acid*
09690	Ammonium acetate, ACS
20840	Cacodylic acid **Sodium** salt Trihydrate
20838	Cacodylic acid **Sodium** salt Trihydrate*
71639	di-**Sodium** hydrogen phosphate anhydrous*
63180	Maleic acid
71180	**Sodium** acetate anhydrous, ACS
71289	**Sodium** azide*
71502	**Sodium** dihydrogen phosphate Dihydrate*

71627	**Sodium** hydrogen carbonate*
71628	**Sodium** hydrogen carbonate, ACS
71689	**Sodium hydroxide**, pellets*
71727	**Sodium** lauryl sulfate*
71999	**Sodium** tetraborate Decahydrate*
27690	sym.-Collidine
90279	Triethanolamine*
71406	tri-**Sodium** citrate Dihydrate
71404	tri-**Sodium** citrate Dihydrate*
93350	Tris(hydroxymethyl)aminomethane, stand-ard titrim. subst.

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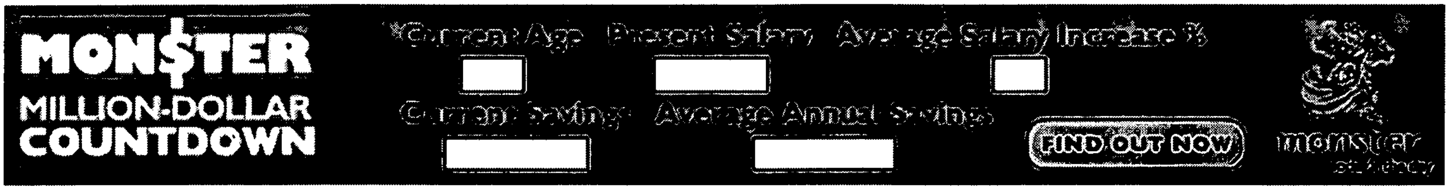

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In blood plasma, the dissolved compounds have an osmotic pressure. A small portion of the total **osmotic pressure** is due to the presence of large protein molecules; this is known as the **colloidal osmotic pressure**, or **oncotic pressure**. Because large plasma proteins can't easily cross through the capillary walls, their effect on the **osmotic pressure** of the capillary interiors will, to some extent, balance out the tendency for fluid to leak out of the capillaries. In conditions where plasma proteins are reduced, e.g. from being lost in the urine (proteinuria) or from malnutrition, the result of the too low **oncotic pressure** can be oedema - excess fluid buildup in the tissues.

Related to hydrostatic pressure.

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Fluid Physiology

2.4 Colloid Osmotic Pressure

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2.4.1 Colloids

Definitions

Colloids is a term used to collectively refer to the large molecular weight (nominally MW > 30,000) particles present in a solution. In normal plasma, the plasma proteins are the major colloids present.

As the colloids are solutes they contribute to the total **osmotic** pressure of the solution. This component due to the colloids is typically quite a small percent of the total **osmotic** pressure. It is referred to as ***colloid osmotic pressure*** (or sometimes as the ***oncotic pressure***).

In plasma, the **oncotic** pressure is only about 0.5% of the total **osmotic** pressure. This may be a small percent but because colloids cannot cross the capillary membrane easily, **oncotic** pressure is extremely important in transcapillary fluid dynamics.

Measurement

Oncotic pressure can be easily measured in the laboratory with instruments called **oncometers**.

The principle is to have 2 chambers which are enclosed and separated from each other by a semi-permeable membrane which is:

- permeable to water and small MW substances, *but*
- not permeable to molecules with a MW greater then 30,000 (ie colloids)

Relative to this membrane, the colloids are the only *effective* solutes present. The reference chamber contains isotonic saline and the test solution is added to the sample chamber. If the test solution contains colloids, water moves from the reference chamber to the sample chamber. The decrease in pressure in the test chamber is detected by a pressure transducer (strain gauge). Modern oncometers can provide accurate results with samples as small as 50 microlitres.

2.4.2 van't Hoff Equation

Osmotic pressure and **oncotic** pressure can be *measured* by suitable instruments. They can also be *calculated* for an ideal solution by appropriate substitutions in the van't Hoff equation.

The van't Hoff Equation

Osmotic pressure = n x (c/M) x RT

where:

- n is the number of particles into which the substance dissociates (n = 1 for plasma proteins)
- c is the concentration in G/l
- M is the MW of the molecules
- c/M is thus the molar concentration of the substance
- R is the universal gas constant
- T is the absolute temperature (K)

As an example, if values are substituted in this equation for a typical plasma sample:

- T = 310K (ie temp of 37C)
- R = 0.082
- n = 1 (for plasma proteins as they do not dissociate)

and:

- Multiplying by 0.001 to convert from Osmoles to mOsmoles
- Multiplying by 760 to convert the result from atmospheres to mmHg
- Multiplying by 280 to convert the **osmotic** pressure per mOsm/kg to a value for plasma with an osmolality of 280 mOsm/kg

then:

Total plasma **osmotic** pressure = 1 x 0.082 x 310 x 0.001 x 760 x 280 = 5409 mmHg

For a plasma osmolality of 280 mOsm/kg at 37C, total **osmotic** pressure is about 5409mmHg (ie about 7.1 atmospheres!)

Each mOsm/kg of solute contributes about 19.32mmHg to the **osmotic** pressure

Now consider the case of plasma proteins alone and calculate the **colloid osmotic** (**oncotic**) pressure.

Using typical values for concentration & MW of the plasma proteins, the protein concentration is about 0.9 mOsmol/kg which predicts an **oncotic** pressure of 17.3 mmHg (ie 19.32 x 0.9). Measurement in an oncometer shows the actual plasma **oncotic** pressure is about 25 mmHg which is equivalent to a plasma protein concentration of 1.3 mmol/kg.

2.4.3 Measured versus predicted values

Why is there a difference between the actual measured value and the value calculated using the van't Hoff equation?

The two reasons are:

- The proteins are charged & non-permeant => Gibbs-Donnan effect
- The proteins are large => 'Excluded Volume' effect

As protein is both charged and non-permeant across the capillary membrane, it sets up a Gibbs-Donnan equilibrium which affects the concentration of the diffusable ions on both sides of the membrane. The net result in this case is an increase in the number of particles per unit volume on the intravascular side of the membrane. The protein concentration appears to be larger than it is because of these extra particles and the effective **oncotic** pressure is therefore increased.

Additionally as protein molecules are large the volume they occupy in the solution is significant and this is another reason for the discrepancy from the van't Hoff equation which is derived for infinitely dilute (ie 'ideal') solutions. This second effect is known as the excluded volume effect.

What is the nature of these extra particles which are contributing an extra 7 to 8 mmHg (equivalent to about 0.4 mOsm/kg) to the measured **oncotic** pressure? They are mostly Na+ ions as these are the cations present in by far the highest concentration. The [Na+] in plasma is increased by about 6 to 7 mmol/l because of the Gibbs-Donnan effect.

This increase of 6 to 7 mmol/l is much more than the 0.4 mOsm/l required to account for the increase in **oncotic** pressure. What is the explanation for this apparant discrepancy? The answer is that there is also a decrease in anion concentration which counteracts much of the increase in cation (ie Na^+) concentration so the *net* change in concentration is an increase of 0.4 mOsmoles/l.

Final note: Additional complicating factors not discussed here are that the net charge on the proteins is affected by:

- temperature
- pH
- types of protein present (eg albumin versus globulins)

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'Fluid Physiology' by Kerry Brandis -from http://www.AnaesthesiaMCQ.com

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PLASBUMIN®-25

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Albumin (Human)

Plasma Substitute/Blood Derivative

Action And Clinical Pharmacology: Each 20 mL vial of albumin (human) 25% supplies the **oncotic** equivalent of approximately 100 mL citrated plasma; 50 mL supplies the **oncotic** equivalent of approximately 250 mL citrated plasma.

When administered i.v. to an adequately hydrated subject, the **oncotic** (colloid **osmotic**) effect of 20 mL albumin (human) 25% is such that it will draw approximately a further 70 mL of fluid from the extravascular tissues into the circulation within 15 minutes, thus increasing the total **blood** volume and reducing both hemoconcentration and whole **blood** viscosity. Accordingly, the main clinical indications are for hypoproteinemic states involving reduced **oncotic** pressure, with or without accompanying edema. Albumin (human) 25% can also be used as a plasma volume expander.

Albumin is a transport protein and it may be useful in severe hemolytic disease in the neonate who is awaiting exchange transfusion. The infused albumin may reduce the level of free bilirubin in the **blood**.

This could also be of importance in acute liver failure where albumin might serve the dual role of supporting plasma **oncotic** pressure, as well as binding excessive plasma bilirubin.

Indications And Clinical Uses: Emergency Treatment of Hypovolemic Shock: Albumin (human) 25% is hyperoncotic and on i.v. infusion will expand the plasma volume by an additional amount, 3 to 4 times the volume actually administered, by withdrawing fluid from the interstitial spaces, provided the patient is normally hydrated interstitially or there is interstitial edema. If the patient is dehydrated, additional crystalloids must be given, or alternatively, albumin (human) 5% should be used. The patient's hemodynamic response should be monitored and the usual precautions against circulatory overload observed. The total dose should not exceed the level of albumin found in the normal individual, i.e., about 2 g/kg body weight in the absence of active bleeding. Although albumin (human) 5% is to be preferred for the usual volume deficits, albumin (human) 25% with appropriate crystalloids may offer therapeutic advantages in **oncotic** deficits or in long-standing shock where treatment has been delayed.

Removal of ascitic fluid from a patient with cirrhosis may cause changes in cardiovascular function and even result in hypovolemic shock. In such circumstances, the use of an albumin infusion may be required to support the **blood** volume.

Burn Therapy: An optimal therapeutic regimen with respect to the administration of colloids, crystalloids, and water following extensive burns has not been established. During the first 24 hours after sustaining thermal injury, large volumes of crystalloids are infused to restore the depleted extracellular fluid volume. Beyond 24 hours albumin (human) 25% can be used to maintain plasma colloid **osmotic** pressure.

Hypoproteinemia With or Without Edema: During major surgery, patients can lose over half of their circulating albumin with the attendant complications of **oncotic** deficit. A similar situation can occur in sepsis or intensive care patients. Treatment with albumin (human) 25% may be of value in such cases.

Adult Respiratory Distress Syndrome (ARDS): This is characterized by deficient oxygenation caused by pulmonary interstitial edema complicating shock and postsurgical conditions. When clinical signs are those of hypoproteinemia with a fluid volume overload, albumin (human) 25% together with a diuretic may play a role in therapy.

Cardiopulmonary Bypass: With the relatively small priming volume required with modern pumps, preoperative dilution of the **blood** using albumin and crystalloid has been shown to be safe and well-tolerated. Although the limit to which the hematocrit and plasma protein concentration can be safely lowered has not been defined, it is common practice to adjust the albumin and crystalloid pump prime to achieve a hematocrit of 20% and a plasma albumin concentration of 2.5 g/100 mL in the patient.

Acute Liver Failure: In the uncommon situation of rapid loss of liver function with or without coma, administration of albumin may serve the double purpose of supporting the colloid **osmotic** pressure of the plasma as well as binding excess plasma bilirubin.

Neonatal Hemolytic Disease: The administration of albumin (human) 25% may be indicated prior to exchange transfusion, in order to bind free bilirubin, thus lessening the risk of kernicterus. A dosage of 1 g/kg body weight is given about 1 hour prior to exchange transfusion. Caution must be observed in hypervolemic infants.

Sequestration of Protein Rich Fluids: This occurs in such conditions as acute peritonitis, pancreatitis, mediastinitis, and extensive cellulitis. The magnitude of loss into the third space may require treatment of reduced volume or **oncotic** activity with an infusion of albumin.

Erythrocyte Resuspension: Albumin may be required to avoid excessive hypoproteinemia, during certain types of exchange transfusion, or with the use of very large volumes of previously frozen or washed red cells. About 25 g of albumin per litre of erythrocytes is commonly used, although the requirements in pre-existent hypoproteinemia or hepatic impairment can be greater. Albumin (human) 25% is added to the isotonic suspension of washed red cells immediately prior to transfusion.

Acute Nephrosis: Certain patients may not respond to cyclophosphamide or steroid therapy. The steroids may even aggravate the underlying edema. In this situation a loop diuretic and 100 mL albumin (human) 25% repeated daily for 7 to 10 days may be helpful in controlling the edema and the patient may then respond to steroid treatment.

Renal Dialysis: Although not part of the regular regimen of renal dialysis albumin (human) 25% may be of value in the treatment of shock or hypotension in these patients. The usual volume administered is about 100 mL, taking particular care to avoid fluid overload as these patients are often fluid overloaded and cannot tolerate substantial volumes of salt solution.

Situations in which albumin administration is not warranted: In chronic nephrosis, infused albumin is promptly excreted by the kidneys with no relief of the chronic edema or effect on the underlying renal lesion. It is of occasional use in the rapid "priming" diuresis of nephrosis. Similarly, in hypoproteinemic states associated with chronic cirrhosis, malabsorption, protein losing enteropathies, pancreatic insufficiency, and undernutrition, the infusion of albumin as a source of protein nutrition is not justified.

Contra-Indications: Certain patients, e.g., those with a history of congestive cardiac failure, renal insufficiency or stabilized chronic anemia, are at special risk of developing circulatory overload. A history of an allergic reaction to albumin is a specific contraindication to usage. tag_WarningWarnings

Manufacturers' Warnings In Clinical States: Solutions which have been frozen should not be used. Do not use if turbid. Do not begin administration more than 4 hours after the container has been entered. Partially used vials must be discarded. Vials which are cracked or which have been previously entered or damaged should not be used, as this may have allowed the entry of microorganisms. Albumin (human) 25% contains no preservative.

Precautions: General: Patients should always be monitored carefully in order to guard against the possibility of circulatory overload. Albumin (human) 25% is hyperoncotic, therefore, in the presence of dehydration, albumin must be given with or followed by addition of fluids.

In hemorrhage the administration of albumin should be supplemented by the transfusion of whole **blood** to treat the relative anemia associated with hemodilution. When circulating **blood** volume has been reduced, hemodilution following the administration of albumin persists for many hours. In patients with a normal **blood** volume, hemodilution lasts for a much shorter period.

The rapid rise in **blood** pressure which may follow the administration of a colloid with positive **oncotic** activity necessitates careful observation to detect and treat severed **blood** vessels which may not have bled at the lower **blood** pressure.

Drug Interactions: Albumin (human) 25%, USP is compatible with whole **blood**, packed red cells, as well as the standard carbohydrate and electrolyte solutions intended for i.v. use. It should, however, not be mixed with protein hydrolysates, amino acid solutions nor those containing alcohol.

Pregnancy: Animal reproduction studies have not been conducted with albumin (human) 25%. It is also not known whether it can cause fetal harm when administered to a pregnant woman or can affect reproduction capacity. It should be given to a pregnant woman only if clearly needed.

Children: Safety and effectiveness in the pediatric population have not been established.

Adverse Reactions: Adverse reactions to albumin are rare. Such reactions may be allergic in nature or due to high plasma protein levels from excessive albumin administration. Allergic manifestations include urticaria, chills, fever, and changes in respiration, pulse and **blood** pressure. tag_DosageDosage

Dosage And Administration: Albumin (human) 25% should always be administered by i.v. infusion. If sodium restriction is required, it may be administered either undiluted or diluted in a sodium-free carbohydrate solution such as 5% dextrose in water.

Hypovolemic Shock: For treatment of hypovolemic shock, the volume administered and the speed of infusion should be adapted to the response of the individual patient.

Burns: After a burn injury (usually beyond 24 hours) there is a close correlation between the amount of albumin infused and the resultant increase in plasma colloid **osmotic** pressure. The aim should be to maintain the plasma albumin concentration in the region of 2.5±0.5 g/100 mL with a plasma **oncotic** pressure of 20 mm Hg (equivalent to a total plasma protein concentration of 5.2 g/100 mL). This is best achieved by the i.v. administration of albumin (human) 25%. The duration of therapy is decided by the loss of protein from the burned areas and in the urine. In addition, oral or parenteral feeding with amino acids should be initiated, as the long-term administration of albumin should not be considered as a source of nutrition.

Hypoproteinemia With or Without Edema: Unless the underlying pathology responsible for the hypoproteinemia can be corrected, the i.v. administration of albumin (human) 25% must be considered purely symptomatic or supportive (see Situations in which albumin administration is not warranted). The usual daily dose of albumin for adults is 50 to 75 g and for children 25 g. Patients with severe hypoproteinemia who continue to lose albumin may require larger quantities. Since hypoproteinemic patients usually have approximately normal **blood** volumes, the rate of administration of albumin (human) 25% should not exceed 2 mL/min, as more rapid injection may precipitate circulatory embarrassment and pulmonary edema.

Other dosage recommendations are given under Indications.

Preparation for Administration: Remove seal to expose stopper. Always swab stopper top immediately with a suitable antiseptic prior to entering vial. Parenteral drug products should be inspected visually for particulate matter and discoloration prior to administration, whenever solution and container permit.

Availability And Storage: Each vial of sterile, aqueous solution for i.v. administration contains albumin (human) 25%, USP: 5 g (in 20 mL), 12.5 g (in 50 mL), 25 g (in 100 mL). The solution also contains sodium caprylate 0.02 M and acetyltryptophan 0.02 M and is buffered with sodium carbonate. Preservative-free. Vials of 20, 50 and 100 mL.

Each vial is heat-treated at 60°C for 10 hours against the possibility of transmitting the hepatitis viruses.

Store at room temperature not exceeding 30°C. Do not use after expiration date. Do not freeze.

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Perfusion & Diffusion in Cryonics Protocol

by Ben Best

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I. BACKGROUND

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Preparing a cryonics patient for cryostorage can involve three distinct stages of alteration of body fluids:

(1) **patient cooldown/cardiopulmonary support**

(2) **blood washout/replacement for patient transport**

(3) **cryoprotectant perfusion**

During patient cooldown/cardiopulmonary support, a cryonics emergency response team or health care personnel may inject a number of medicaments to minimize ischemic injury and facilitate cryopreservation. The first and most important of these medicaments would be **heparin**, to prevent blood clotting. (For more details on the initial cooldown process, see Emergency Preparedness for a Local Cryonics Group).

Once the patient is cooled, the blood can be washed-out and replaced with a solution intended to keep organs/tissues alive while the patient is being transported to a cryonics facility. At the cryonics facility the organ/tissue preservation solution is replaced with the cryopreservation solution intended to prevent ice formation when the patient is further cooled to temperatures of -140°C (glass transition temperature) or -196°C (liquid nitrogen temperature) for long-term storage.

For both organ/tissue preservation & cryoprotection it is necessary to replace the fluid contents of blood vessels & tissue cells with other fluids. The process of injecting & circulating fluids through blood vessels is called **perfusion**. The passive process by which fluids enter & exit both blood vessels & cells is called **diffusion**.

Another important distinction to remember in replacing body fluids is the distinction between **tissue swelling** (edema) and **cell swelling**. **Edema** occurs when fluids leak out of blood vessels into the extracellular space (the space between cells in tissues). Injury to blood vessels can result in edema, but edema can also result from water leaking out of vessels when there is nothing (like albumin) to prevent the leakage. Edema can impede perfusion considerably, and is frequently a problem in cryonics patients who have suffered ischemic or other forms of blood vessel damage.

Cell swelling occurs when there is a lower concentration of dissolved molecules (solutes) outside cells than inside cells. Conversely, when a high concentration of solutes surrounds a cell, water rushes out of the cell causing the cell to shrink. To prevent either shrinkage or swelling of a cell there must be an **osmotic balance** of molecules & ions between the liquids outside the cell & inside the cell. Even if a cell does not burst or collapse due to **osmotic** imbalance, a sudden change in **osmotic** balance can severely injure cells. Maintaining ***osmotic balance*** of the fluids outside & inside cells is as important as maintaining ***oncotic balance***, ie, balance of fluids inside & outside of blood vessels.

Sterling's Hypothesis states that at equilibrium there will be a balance between hydrostatic pressure in the capillaries and hydrostatic pressure in the interstitial fluid between capillary walls and tissue cells -- as well as between the **oncotic** pressure in the capillary and the **oncotic** pressure in the interstitial fluid. In most of the body, capillary membranes are permeable to the low molecular weight solutes in the blood, but impermeable to the large proteins. Capillary membranes in the brain are not only impermeable to proteins, but are even impermeable to low moleuclar weight solutes like Na^+ and Cl^- -- an impermeability referred to as the **blood-brain barrier**. For the blood-brain barrier, no distinction need be made between **osmotic** and **oncotic** pressure because **oncotic** pressure is mostly due to the **osmotic** pressure of the small solutes. This fact is relevant for cryonics because infusion of small solutes -- like mannitol or hypertonic saline -- can dehydreate the brain or prevent edema.

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II. VISCOSITY AND TURBULENCE

A critical distinction is made in fluid mechanics between laminar flow and turbulent flow in a pipe. For **laminar flow** elements of a liquid follow straight streamlines, where the velocity of a streamline is highest in the center of the vessel and slowest close to the walls. **Turbulent flow** is characterized by eddies & chaotic motion which can substantially increase resistance and reduce flow rate. The Reynolds number is an empirically determined dimensionless quantity which is used to predict whether flow will be laminar or turbulent -- with 2000 being the lower limit for turbulent flow.

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Turbulent flow could potentially be a problem in cryonics if it reduced perfusion rate or increased the amount of pressure required to **maintain** a perfusion rate. It is doubtful that turbulent flow ever plays a role in cryonics perfusion, however. Even for a subject at body temperature (37°C) Reynolds numbers in excess of 2000 are only seen in the very largest blood vessels: the aorta and the vena cava.

The formula for Reynolds number is:

$$Re = \frac{\rho v D}{\mu}$$

ρ = fluid density (rho)
v = fluid viscosity
D = vessel diameter
μ = viscosity

The fact that diameter (D) is in the numerator indicates that only high diameter vessels have high Reynolds number. Velocity (v), also in the numerator, is highest in the aorta & arteries. But the use of cryoprotectants and the increase in viscosity (μ) with declining temperature essentially guarantee that turbulent flow will not occur in a cryonics patient.

More serious for cryonics is the Hagen-Poisseuille Law, which describes the relationship between flow-rate and driving-pressure:

$$\text{Flow Rate} = \frac{\textbf{pressure} \times (\textbf{radius})^4}{\textbf{length} \times \textbf{viscosity}}$$

Typically in cryonics the flow rate will be one or two liters per minute when the pressure is around 80 mmHg. But because flow rate varies inversely with viscosity and varies directly with pressure, pressure must be increased to **maintain** flow rates when cryoprotectant viscosity increases with lowering temperature. This poses a serious problem because blood vessels become more fragile with lowering temperature. If blood vessels burst the perfusion can fail.

At 20°C glycerol is about 25% more dense (ρ=rho, in the numerator) than water. But the role of viscosity is far more dramatic, with high viscosity in the denominator reducing Reynolds number considerably. The viscosity of water approximately doubles from 37°C to 10°C, but the viscosity of glycerol increases by a factor of ten (roughly 4 Poise to 40 Poise). At 37°C glycerol is nearly 600 times more viscous than water, but at 10°C it is about 2,600 times more viscous.

Although turbulence is not a concern in cryonics, the increase in viscosity of cryoprotectant with lowering temperature certainly is. Fortunately, the newer vitrification mixtures are less viscous than glycerol.

The most common strategy in cryonics has been to cool the patient from 37°C to 10°C as rapidly as possible and to perfuse with cryoprotectant at 10°C. Lowering body temperature reduces metabolism considerably, thereby lessening the amount of oxygen & nutrient required to keep tissues alive. Cryoprotectant toxicity drops as temperature declines. But the very dramatic more-than-exponential increase in cryoprotectant viscosity with lowering temperature poses a significant problem for effective perfusion. When open circuit perfusion is used, a higher temperature may be preferable because the opportunity for diffusion time into cells is so limited (about 2 hours -- 1 hour for the head, 1 hour for the body) -- although ischemic damage is difficult to quantify.

With closed circuit perfusion, the perfusion times are longer -- up to 5 hours. If a good carrier solution is used for the cryoprotectant the tissues may receive adequate nutrient. This, along with the oxygen carrying-capacity of water at low temperature, may limit ischemic damage while allowing time for cells to become fully loaded with cryoprotectant. If ischemic damage can be safely prevented in perfusion, the only critical issues for temperature selection are the relative benefits of reduced cryoprotectant toxicity at lower temperatures as against increased chilling injury. The fact that the more-than-exponential increase in viscosity with lowering temperature will increase perfusion time will not be problematic if the risk of ischemia is minimized.

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III. BLOOD WASHOUT & REPLACEMENT

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Early in the process of preparing a cryonics patient for cryopreservation it is important to replace the blood. Provided anti-coagulant such as heparin is injected into the patient, blood can remain in a patient whose tissue viability is being maintained by cardiopulmonary support (circulation of oxygenated blood) in the early stages of cooling.

As body temperature approaches 10°C, however, metabolic rate has slowed greatly and the oxygen-carrying capacity of blood hemoglobin is no longer required. Cool water, in fact, may carry adequate dissolved oxygen at low temperatures. (Water near freezing temperature can hold nearly three times as much dissolved oxygen as water near boiling temperature.) The tendency of blood to agglutinate and clog blood vessels becomes a serious problem at low temperature -- so the blood should be replaced if this does not cause other problems (such as delay and reperfusion injury.)

Typically a cryonics patient deanimates at a considerable distance from a cryonics facility and must be transported before cryoprotectant (antifreeze compound such as glycerol) can be perfused. Blood is washed-out and replaced with an isotonic (ie, osmotically the same as saline) solution, such as **Ringer's solution**. The patient is then transported to the cryonics facility at water-ice temperature. Freezing must be avoided because ice crystals would damage cells & blood vessels to such an extent as to prevent effective cryoprotectant perfusion. Water-ice temperature will not freeze tissues because tissues are salty.

Replacing blood with a saline-like solution for patient transport, however, does not do a good job of maintaining tissue viability or preventing edema. For this reason the organ preservation solution **Viaspan®**, rather than Ringer's solution, has been used for cryopatient transport. Blood is not simply an isotonic solution carrying blood cells. Blood contains albumin, which attracts water and keeps the water from leaving blood vessels and going into tissues (maintains **oncotic** balance). Tissues which are swollen (edematous) resist cryoprotectant perfusion. One of the most important ingredients in Viaspan® preventing edema is **HydroxyEthyl Starch (HES)**, which attracts water in much the way albumin attracts water -- acting as an **oncotic agent** by keeping water in the blood vessels. Viaspan® contains **potassium lactobionate** to help **maintain osmotic** balance.

Viaspan® (DuPont Merck Pharmaceuticals) contains other ingredients to **maintain** tissue viability, such as glucose, glutathione, etc. (the full formula can be found on the Viaspan® website). Viaspan® is FDA approved for preservation of liver, kidney & pancreas, but is used off-label for heart & lung transplants. Viaspan® is being challenged in the marketplace for all these applications by the Hypothermosol (Cryomedical Sciences, BioLife Technologies) line of preservation solutions.

Rather than use these expensive commercial products, Alcor uses a preservation solution developed by Jerry Leaf & Mike Darwin called **MHP-2**. MHP-2 is so-called because it is a Perfusate (P) which contains mannitol (M) as an extracellular **osmotic agent** and hydroxyethyl starch (H) as an **oncotic agent** to prevent edema. MHP-2 also contains ingredients to **maintain** tissue viability. Lactobionate permeates cells less than mannitol and can thus **maintain osmotic** balance for longer periods of time, but mannitol is much less expensive. Mannitol also has an additional effect in the brain. Because of the unique tightness of brain capillary endothelial cell junctions ("blood brain barrier"), mannitol does not normally penetrate into the extravascular space of the brain. This means that mannitol can act like an **oncotic agent** for the brain. If the blood brain barrier is intact, mannitol will suck water out of the extravascular space. The brain is the only place that mannitol can do this, and that's why a mannitol is effective for inhibiting edema of the brain -- but ***only*** if there is not extensive ischemic damage to the blood brain barrier. (Mannitol has yet another benefit in that it scavenges hydroxyl radical [CHEM.-BIOL. INTERACTIONS 72:229-255 (1989)]).

(For the formula of MHP-2 see Table II of CryoMsg 4474 or Table VII of CryoMsg 2874 -- which also contains the formula for Viaspan in Table V.)

The initial perfusate can also contain other ingredients to assist in reducing damage to the cryonics patient. Anticoagulants can reduce clotting problems, and antibiotics can reduce bacterial damage. Damaging effects of ischemia can be reduced with antioxidants, antiacidifiers, an iron chelator and a calcium channel blocker.

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IV. CRYOPROTECTANT PERFUSION

Once the patient is at the cryonics facility the transport solution can be replaced with a cryoprotectant solution. A perfusion temperature of 10°C gives the best tradeoff of avoiding the high viscosity of lower temperatures and at the same time limiting the ischemic tissue degradation and cryoprotectant toxicity that would be seen at higher temperatures. (Cryonicists usually worry more about ischemic damage than cryoprotectant toxicity due to a belief that ischemic damage has a greater likelihood of being irreversible -- irreparable by future molecular-repair technology.)

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Cryoprotectants are used in cryonics to reduce freezing damage by prevention of ice formation (see Vitrification in

Cryonics). Although it seems plausible that our brains may be damaged by freezing in a way that can be repaired, it is possible that freezing damage is really freezing destruction -- destruction beyond all future repair due to scrambling of tissue into molecular debris. If we were certain of future repair, it would make much more sense to immediately thrust cryonics patients into liquid nitrogen upon deanimation rather than to waste time or expense on cryoprotectant perfusion. Cryoprotectants may not only increase the possibility of future repair, they may reduce the estimated time the patient needs to remain in liquid nitrogen -- a vulnerable condition in which a patient could be destroyed due to negligence, accident or malevolence.

Cryoprotectants should be sterilized to prevent the growth of bacteria. Sterilization of cryoprotectants by heating can cause the formation of carbon-carbon double-bonds, which are evident by a yellowing of the cryoprotectant. Only a few such double-bonds can produce the yellow appearance, so the fact of yellowing is not evidence that the cryoprotectant is no longer serviceable. But a preferable method of cryoprotectant sterilization is filtration through a 0.2 micron filter.

Aside from the choice of cryoprotectants, a major concern is the way cryoprotectant is administered. For example, glycerol (the standard cryoprotectant used in cryonics for many years) can either be administered full-strength or it can be introduced in gradually increasing concentrations. (Under optimum conditions, glycerol results in 80% vitrification and 20% ice formation. Glycerol has been replaced by better cryoprotectants that can vitrify without any ice formation, but I will use glycerol as my example cryoprotectant.) A patient should not be perfused with a 100% solution of glycerol or other cryoprotectant. It is prudent to begin perfusion with low concentrations of cryoprotectant because water can diffuse out of cells thousands of times more rapidly than glycerol diffuses into cells. Using gradually increasing concentrations of glycerol (ramping) prevents the **osmotic** damage this differential could cause.

Cells are much more permeable to water than they are to glycerol. Platelets & granulocytes, for example, are 4,000 times more permeable to water than they are to glycerol [*1]. When a cell is exposed to high-strength glycerol, osmosis causes water to rush out of the cells, causing the cells to shrink. Only very gradually does the glycerol cross cell membranes to enter the cell. For isolated cells, the halftime (time to halve the difference between a given glycerol concentration in a granulocyte and the maximum possible concentration) is 1.3 minutes [*2] -- but tissues & organs would require more time because their cells are less accessible. Even after equilibration, however, the concentration of glycerol inside neutrophilic granulocytes never rises above 78% of the concentration outside the cells.

Rapid shrinking of cells can kill them. When granulocyte cells shrink to 68% of their normal volume, cell survival drops -- and severe cell death occurs below 55% [*3]. Increasing glycerol concentration from 0.5 molar to 1.0 molar reduces granulocyte survival from 40% to 20% at 0ºC [*3]. Cell shrinkage may directly damage the cell (and cell membrane) due to structural resistance from the cell cytoskeleton and high compression of other cell constituents [*4]. (If damage is maximum at 1.0 molar, the concentrations up to 7.5 molar used for cryonics protocols may be of little additional damage.)

Not only is cell shrinkage damaging, but rapid passage of water across cell membranes physically damages the membranes. The higher the concentration difference between glycerol inside the cell and glycerol outside the cell, the greater the water molecule velocity and the greater the cell membrane damage (up to a maximum) [*5]. Even more damage may occur to the blood vessels. Rapid addition of glycerol causes endothelial cells to shrink -- thereby breaking the junctions between the cells [*6].

For cryonics purposes some vascular damage can actually be an advantage insofar as it increases diffusion -- and vascular repair may be an easy task for future science. In fact, the breakdown of the blood-brain barrier in the 1.8-2.2 molar glycerol range is essential for perfusion of the brain -- as long as damaging tissue edema (swelling) can be avoided. In general, if **osmotic** damage is similar to types of cryoprotectant toxicity that simply denatures enzymes rather than destroys structures containing information essential to personal identity (consciousness, selfhood), then **osmotic** damage may be far less serious than freezing damage. Unfortunately, it is difficult to draw firm conclusions about what damage is reparable and what structures are essential for personal identity -- and it is wise to not take excessive risk about these matters.

Osmotic damage by glycerol can be reduced in cryonics protocol by introducing the glycerol in gradually increasing concentrations -- rather than perfusing with glycerol full-strength. Also, allowing more time for glycerol equilibration gives time for cells more distant from blood vessels to receive glycerol. The best results are achieved with small increases of glycerol initially, with accelerating increase in concentration. An analogous procedure is used in adding cryoprotectant (DMSO, DiMethylSulfOxide) to human embryos being prepared for storage in liquid nitrogen (PBI 10 minutes, 0.25M DMSO 10 minutes, 0.5M DMSO 10 minutes, 1.0M DMSO 10 minutes, 1.5M DMSO 10 minutes) [*7].

Closed-circuit perfusion (with perfusion solution following a circuit both inside & outside the patient's body) is contrasted with the **open-circuit perfusion** used by funeral directors for embalming. In the open-circuit perfusion of embalming, fluid is pumped into a large artery of the corpse and forces-out blood from a large vein -- and this blood is discarded.

A closed-circuit perfusion, as illustrated in the diagram, can be set up at low cost for gradual introduction of glycerol into cryonics patients. As shown in the diagram, the perfusion circuit bypasses the heart. Perfusate enters the patient through a cannula in the femoral (leg) artery and exits from a cannula in the femoral vein on the same leg. Flowing upwards from the femoral artery, the perfusate enters the arch of the aorta (where blood normally exits the heart), but is blocked from entering the heart. Instead, the perfusate flows through the distribution arteries of the aorta, notably to the head and brain. Returning in the veins, the perfusate again bypasses the heart and flows downward to the femoral vein where it exits. A better alternative to the femoral circuit, however, is to surgically open the chest to cannulate the heart aorta (for input) and atrium (for output).

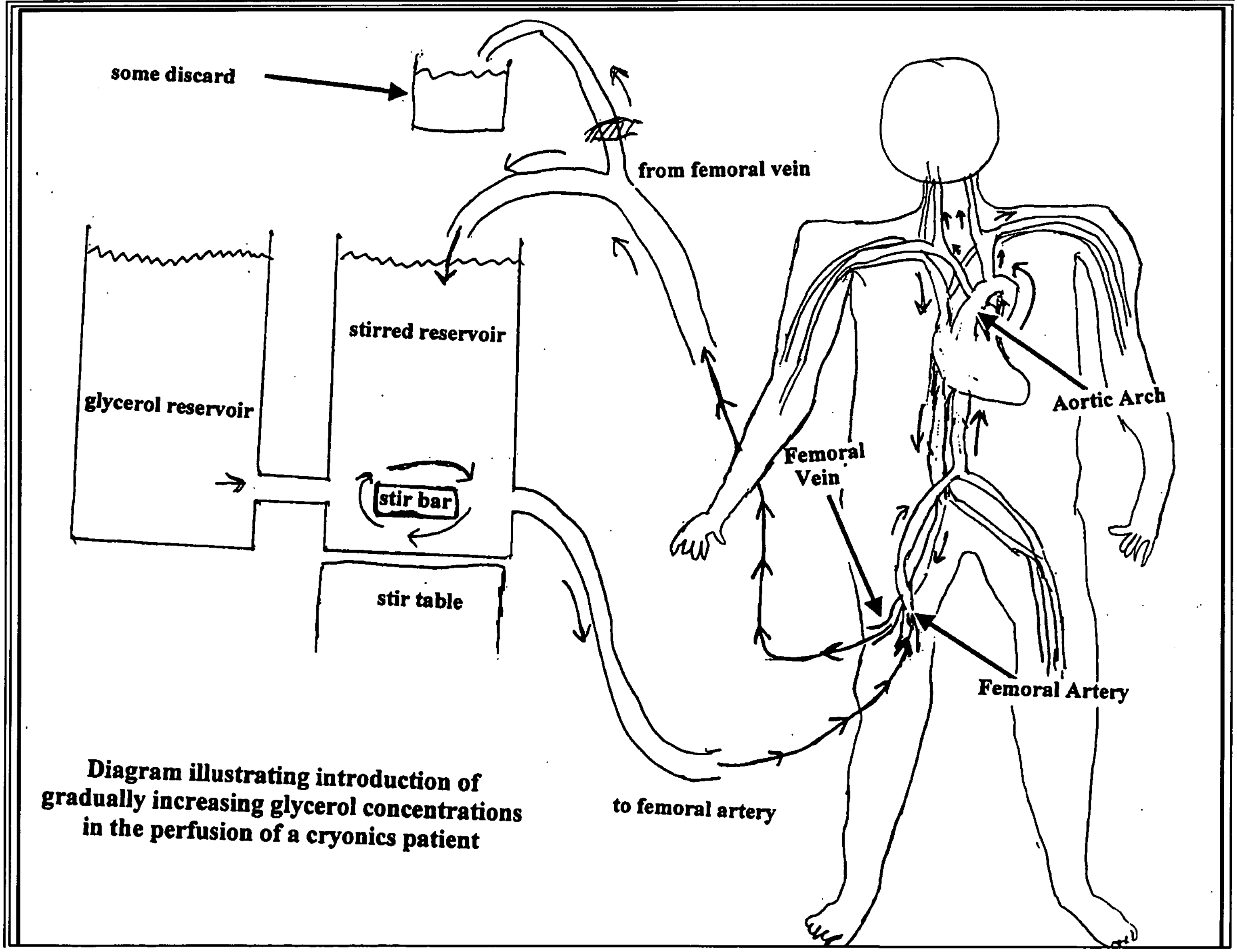


Diagram illustrating introduction of gradually increasing glycerol concentrations in the perfusion of a cryonics patient

Closed Circuit Perfusion of a Cryonics Patient

Although it is not shown in the diagram, there will be a pump in the circuit to **maintain** pressure and fluid movement. A **roller pump**, rather than an embalmer's pump, should be used. A roller pump achieves pumping action by the use of rollers on the exterior of flexible tubing that forces fluids through the tube without contaminating those fluids. Embalmer's pumps may use pressures much higher than those suitable for cryonics, resulting in blood vessel damage. Embalmer's pumps are also easily contaminated (and hard to clean), unless a filter is used. Contamination doesn't matter much in embalming, but in cryonics contaminants entering the patient through the pump can damage blood vessels, interfering with perfusion. If an embalmer's pump is used for cryonics purposes, ensure that the pressure can be lowered to a suitable level and that it is cleaned and sterilized. The main advantage of roller pumps, however, is the fact that they provide a closed circuit, whereas embalmer's pumps are open-circuit. Roller pumps are generally calibrated in litres per minute, and a flow rate of 1.5 to 2 litres per minute will be necessary to achieve the desired perfusion pressure of approximately 80 mmHg.

Outside the patient, some of the drainage is discarded, but most is returned to a circulating (stirred) reservoir connected to a concentrated reservoir of glycerol. The circulating reservoir is initially ***carrier solution*** which gradually becomes increasingly concentrated with glycerol as the stirring and recirculation proceed. The circulating reservoir can be stirred from the bottom by a magnetic stir bar on a stir table and/or from the top by an eggbeater-type stirring device. The stirring will draw glycerol from the glycerol reservoir, and pumping of the perfusate should also actively draw liquid from the glycerol reservoir. Gradually a higher and higher concentration of glycerol is included in the perfusate and the **osmotic** shock of full-strength glycerol is avoided.

The ***carrier solution*** for the cryoprotectant should perform similar tissue preservation functions as is performed by the transport solution, and should be carefully mixed with the cryoprotectant so as to avoid deviations from isotonicity which could result in dehydration or swelling & bursting of cells. The carrier solution will help keep cells alive during cryoprotectant perfusion.

An excellent carrier solution for cryonics purposes would be **RPS-2** (Renal Preservation Solution number 2), which was developed by Dr. Gregory Fahy in 1981 as a result of studies on kidney slices. More recently Dr. Fahy used RPS-2 as the carrier solution in cryopreserving hippocampal slices -- an indication that it is well-suited for brain tissue as well as for kidney. RPS-2 not only helps **maintain** hippocampal slice viability, it reduces the amount of cryoprotectant needed because it has cryoprotectant (colligative) properties of its own. The formulation of RPS-2 is: K_2HPO_4, 7.2mM; reduced glutathione, 5mM; adenine HCl, 1mM; dextrose, 180mM; KCl, 28.2mM; $NaHCO_3$, 10mM; plus calcium & magnesium [*8].

The glycerol reservoir will not in general contain pure glycerol (although in principle it could), but rather a "terminal concentration" solution of glycerol that is equal or slightly above the final target concentration. As perfusion proceeds and drainage to discard proceeds, the level of both reservoirs drops in tandem until both reservoirs are nearly empty, at which point the circuit concentration will have reached the glycerol reservoir concentration. Provided that the two reservoirs are the same size and same vertical elevation, the gradient will be linear over time (if the drainage rate to discard was constant).

For glycerol to perfuse into cells there must be constant exposure to glycerol surrounding the cells -- and there must be pressure to **maintain** that exposure. In a living animal the heart maintains blood pressure that forces blood through the capillaries and forces nutrients into cells. A dead animal with no blood pressure -- and which is being perfused with glycerol -- also requires pressure for the capillaries to remain open and for glycerol to be maintained at high concentrations around cells.

In open-circuit perfusion there are only a few episodic surges of pressure. These do not open capillaries very long nor do they **maintain** a pressure that will assist diffusion of glycerol into cells. Nor does open-circuit perfusion allow for removal of water as it is replaced by glycerol. Alcor found that closed-circuit perfusion must be maintained for 5-7 hours for full equilibration of glycerol, because the diffusion rate of water out of cells is thousands of times the rate at which glycerol enters cells. Of course, it would be possible to pump glycerol into a patient for 5-7 hours with open-circuit perfusion, but only by using thousands of dollars worth of glycerol. The newer vitrification cryoprotectants used by Alcor are vastly more expensive than glycerol. When using expensive cryoprotectants it makes far more sense to recirculate in a closed circuit. Closed-circuit perfusion also has the benefit of allowing for ongoing monitoring of physiological changes occurring in the patient's body during the perfusion process. Open-circuit with an inexpensive cryoprotectant has the advantage of avoiding recirculation of toxins.

Improper mixing of perfusate containing high levels of cryoprotectant can result in a phenomenon that ***appears*** to be high viscosity, but in reality is edema. If, for example, isotonic carrier solution is mixed half-and-half with cryoprotectant solution an open circuit perfusion may have to be halted when no further perfusate will go into the patient. The problem is caused not by viscosity, but by the fact that the isotonic solution became hypotonic due to dilution with cryoprotectant -- causing the cells to swell and forcing perfusion to end. In closed-circuit perfusion, the cryoprotectant concentrate reservoir contains cryoprotectant at about 125% the terminal concentration in a vehicle of isotonic carrier solution so that when reservoir concentrate is mixed with isotonic carrier there is no change in tonicity.

Newer cryoprotectants are less viscous than glycerol, so perfusions can be done in 3-4 hours or less. After 15 minutes of perfusion with carrier solution, cryoprotectant concentration linearly increases at a rate of 50 millimolar per minute until full concentration is reached -- in about two hours (a protocol developed on the basis of minimizing **osmotic** damage when perfusing kidneys). Perfusion is increased for an additional hour or two until the cryoprotectant has fully diffused into cells (as indicated by similarity of afflux and efflux cryoprotectant concentrations).

Only after a few hours of closed-circuit perfusion is the concentration of cryoprotectant exiting the cryonics patient equal to the concentration of cryoprotectant entering the patient. Only an extended period of sustained pressure will keep capillaries open, and otherwise facilitate diffusion of cryoprotectant into cells. And the exiting cryoprotectant concentration will equal the entering cryoprotectant concentration only when the tissues are fully loaded with cryoprotectant. One or more burr holes are made in the skull, and a refractometer is used to verify that terminal cryoprotectant concentration has been reached in the brain.

(A refractometer measures the **index of refraction** of a liquid, ie, the ratio of the speed of light in the liquid and the speed of light in a vacuum (or air). Light changes speed when it strikes the boundary of two media, thus causing a change in angle if it strikes the new medium at an angle. Because the refractive index is a ratio of two quantities having the same units, it is unitless. Sodium vapor in an electric arc produces an excitation between the 3s and 3p orbitals resulting in yellow-orange light of 589nm -- what Joseph Fraunhofer called the "D line". Insofar as the sodium "D line" was the first convenient source of monochromatic light, it became the standard for refractometry. The refractive index of a liquid is thus a high-precision 5-digit number between 1.3000 and 1.7000 at a specific temperature, measured at the sodium D line wavelength. For example, the refractive index of glycerol at 25°C -- n_D^{25} -- is 1.4730.)

Closed-circuit perfusion may be necessary for removal of water as well as loading of cryoprotectant if it is true that open-circuit perfusion cannot remove water effectively.

One could imagine that the additional time spent doing closed-circuit (rather than open-circuit) perfusion means increased damage due to above-zero temperature. But most cells are still alive and metabolizing very slowly at 10°C. Viaspan®, RPS-2 and other organ preservation solutions are designed to keep tissues alive for extended periods at near-zero temperatures -- certainly for the time required for closed-circuit perfusion. Ramping (slowly increasing concentration) of cryoprotectant should be done in such a way that the ion and mannitol or lactobionate concentration remains unchanged in the perfusate. Ramping is not an osmotically neutral process, however, because cryoprotectant is expected to dehydrate tissues.

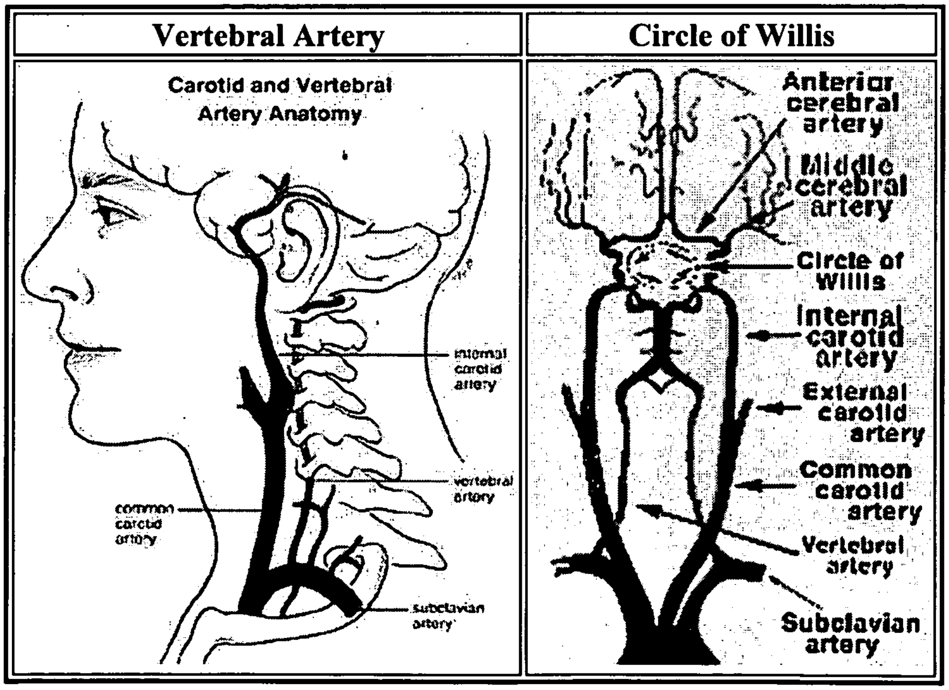
Ramping at the rate of 2-4 molar per hour increase of glycerol concentration is slow enough to allow full diffusion of glycerol into tissues. Cell shrinkage due to diffusion of water from cells is followed by slow cell swelling due to the gradual diffusion of glycerol into cells. Dehydration of epithelial cells in the blood vessels by glycerol ramping facilitates perfusion by making the vessels wider. If the ramping rate is too slow, the epithelial cells become loaded with glycerol quickly enough that the vessel-widening advantage is lost.

Care must be taken that the concentration of non-penetrating solutes (such as mannitol) in the carrier solution is equal to that in the cells -- normally 300mM (millimolar) concentration. If the concentration of nonpenetrating solutes in the carrier solution is hypotonic -- 150mM, for example -- cells will swell to twice their volume irrespective of the glycerol concentration. This swelling would occur first in the epithelial cells, which could seriously impede the process of perfusion. Faster ramping would lessen this effect by dehydration of the epithelial cells, but the increased rate would be too rapid to allow full diffusion of glycerol into the tissues. It is better to avoid these problems by maintaining a carrier solution concentration of nonpenetrating solutes at 300mM to match that in cells.

Although glycerol has historically been the cryoprotectant used in cryonics, the perfusion process described should be much the same with the newer, more effective, cryoprotectants now being used in cryonics. Cryoprotectant toxicity varies directly with temperature, but cryoprotectant viscosity varies inversely with temperature. There is therefore a trade-off between perfusing at a higher temperature for more rapid cryoprotectant penetration, and suffering the increased toxicity of higher temperature. Unlike **osmotic** damage, however, toxicity may affect viability through biochemical rather that structural damage and thereby be of less concern for future repair. Ischemic injury is likely to be minimal due to nutrient & oxygen in the carrier solution. by more time at higher temperature, however, is likely to increase structural damage.

Some cryonics protocols are beginning the introduction of cryoprotectant at 10°C and finishing at 5°C. A near-term objective is to be able to introduce half the cryoprotectant at 10°C and the other half at -10°C. It seems like a good strategy to add the least toxic components of a cryoprotectant cocktail first (at higher temperatures) and the most toxic components at lower temperature -- or simply to increase cryoprotectant concentration as temperature drops. (This technique was used successfully in The Hippocampal Slice Cryopreservation Project.)

When perfusing heads, rather than whole body patients, the sternum can be cut (median sternotomy) for direct access to the aorta and superior vena cava. By clamping-off the descending aorta and applying tourniquets to the arms, a closed circuit could be achieved to the head. A closed circuit to the brain could not be established through the carotid arteries and jugular veins because the vertebral arteries also carry blood to the brain. The carotids & vertebrals can anastomose at the Circle of Willis, however, so full perfusion of the brain should be possible even without use of the vertebrals -- by open circuit. But the Circle of Willis is often incomplete -- preventing full brain perfusion when using the carotid arteries alone. Posterior communicating arteries are threadlike or non-existence in a significant number of cases [ANNALS OF OTOLOGY, RHINOLOGY AND LARYNGOLOGY 112:657-664 (2003)]. Atherosclerosis adds to the problem -- nearly 60% of stroke victims have nonfunctional posterior collateral pathways, making circle of Willis deficiencies a risk factor for stroke [CARDIOVASCULAR DISEASES 16:191-198 (2002)].


Vertebral Artery

Circle of Willis

Attempting to access the vertebrals through the neck is very difficult because they run so close to the spine. But an incision can be made at the collarbone to gain access to the vertebral arteries though the subclavian artery. Perfusing through the vertebrals and the carotids insures that perfusion of the brain is complete even if the Circle of Willis is not compete. If only the brain is to be perfused and not the head and face, then the external carotid artery would be clamped-off, but the external carotid is very difficult to access. The Cryonics Institute succeeded in doing a collarbone access with its 69th patient. Alcor, however, simply removes the head from the cryonics patient and perfuses directly through the carotids and vertebrals -- and recycles the drippings in a simulation of "closed circuit".

Other tricks may eventually be invoked to improve perfusion, diffusion & vitrification -- and to reduce toxicity. High pressures are currently cumbersome & expensive to use, but future equipment may change that. Ultrasound has been suggested as a means of improving diffusion of cryoprotectant into cells. Sugars, which are cryoprotective, could be included in the perfusate -- along with insulin -- to both increase intracellular vitrification and to boost intracellular resistance to ischemic injury.

There is seemingly no limit to the amount of expense that could be incurred in attempting to reduce the damage done to a patient in cryopreparation. A cost-benefit trade-off must be made between achieving minimal damage an an inexpensive protocol. If the structural basis of personal identity is preserved, protocols to **maintain** cell viability would be less important since molecular repair technology could eventually reconstruct the person anyway.

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V. REFERENCES

[*1] CRYOBIOLOGY 23(2):116-125 (1986)

[*2] EXPERIMENTAL HEMATOLOGY 10(5):423-434 (1982)

[*3] AMERICAN JOURNAL OF PHYSIOLOGY 247(5 Pt 1):C382-389 (1984)

[*4] HUMAN REPRODUCTION 10(5):1109-1122 (1995)

[*5] BIOPHYSICS JOURNAL 66(2 Pt 1):532-541 (1994)

[*6] CRYOBIOLOGY 23(6):500-511 (1986)

[*7] FERTILITY AND STERILITY 46(1):1-12 (1986)

[*8] CRYOBIOLOGY 27(5):492-510 (1990)

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on·cot·ic (ŏng-kŏt′ĭk)
adj.

1. Of or relating to the formation of tumors.
2. Of or caused by a condition of swelling.

5968726

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Buffer systems maintian a constant pH in blood

The body maintains the pH of **blood** at around 7.4. If the pH level changes just a few tenths of a pH unit, serious health consequences can result. A decrease in **blood** ph is called **acidosis**, an increase is called **alkalosis**

Three different **buffer** systems exist in **blood**, the bicarbonate **buffer** and the phosphate **buffer** are composed of "simple" chemicals. In addition the carbonyl groups (-COOH) and the amide group (-NH2) present on proteins allow some of these to act as buffers. The bicarbonate **buffer** and the phospate **buffer** can be described by the following equilibria:

- What is the optimal pH for the bicarbonate **buffer**? [Answer]
- What is the optimal pH for the phosphate **buffer**? [Answer]
- In each **buffer**, which species react with added acid? [Answer]
- In each **buffer**, which species react with added base? [Answer]

The pH for the bicarbonate buffer seems to be outside of its ideal range

Buffer capacity is usually defined as +/- 1 pH unit of the pKa. Notice that the pH of **blood** is is one unit away from the pKa of carbonic acid. Calculate the ratio of bicarbonate to carbonic acid implied by this. [Answer]

The ratio of bicarbonate to carbonic acid seems to be quite large (and in general this system would not be considered ideal for maintaining a pH of 7.4). However, physiologic conditions make this **buffer** ideal because:

- excess acid is produced by the body as a byproduct of exercise (lactic acid) making the higher concentration of the conjugate base (bicarbonate) an advantage
- the body has the ability to obtain more carbonic acid by reabsorbing carbon dioxide from the lungs. Recall that carbonic acid is an aqueous solution of carbon dioxide.

In addition, the phosphate **buffer** as well as the buffering ability of proteins in plasma are also available to maintain **blood** pH.

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ACIDS AND BASES

What is an **acid** or a **base**?
Properties of acids.
Properties of bases.
Strong acids and bases.
Solubility and dissociation.
Overview of pH.
The pH box.
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WHAT IS AN **ACID** OR A **BASE**?

By the 1884 definition of Svante Arrhenius (Sweden), an **acid** is a material that can release a proton or hydrogen ion (H^+). Hydrogen chloride in water solution ionizes and becomes hydrogen ions and chloride ions. If that is the case, a **base**, or alkali, is a material that can donate a hydroxide ion (OH^-). Sodium hydroxide in water solution becomes sodium ions and hydroxide ions. By the definition of both Thomas Lowry (England) or J.N. Brønsted (Denmark) working independently in 1923, an **acid** is a material that donates a proton and a **base** is a material that can accept a proton. Was Arrhenius erroneous? $| 8-) No. The Arrhenius definition serves well for a limited use. We are going to use the Arrhenius definitions most of the time. The Lowry- Brønsted definition is broader, including some ideas that might not initially seem to be **acid** and **base** types of interaction. Every ion dissociation that involves a hydrogen or hydroxide ion could be considered an **acid- base** reaction. Just as with the Arrhenius definition, all the familiar materials we call acids are also acids in the Lowry- Brønsted model. The G.N. Lewis (1923) idea of acids and bases is broader than the Lowry- Brønsted model. The Lewis definitions are: Acids are elecron pair acceptors and bases are electron pair donors.

We can consider the same idea in the Lowry- Brønsted fashion. Each ionizable pair has a proton donor and a proton acceptor. Acids are paired with bases. One can accept a proton and the other can donate a proton. Each **acid** has a proton available (an ionizable hydrogen) and another part, called the ***conjugate base***. When the **acid** ionizes, the hydrogen ion is the **acid** and the rest of the original **acid** is the conjugate **base**. Nitric **acid**, HNO_3, ***dissociates*** (splits) into a hydrogen ion and a nitrate ion. The hydrogen almost immediately joins to a water molecule to make a hydronium ion. The nitrate ion is the conjugate **base** of the hydrogen ion. In the second part of the reaction, water is a **base** (because it can accept a proton) and the hydronium ion is its conjugate **base**.

$$\underset{\text{ACID}}{HNO_3} + \underset{\text{BASE}}{H_2O} \rightarrow \underset{\substack{\text{CONJUGATE}\\ \text{BASE}}}{NO_3^-} + \underset{\substack{\text{CONJUGATE}\\ \text{ACID}}}{H_3O^+}$$

In a way, there is no such thing as a hydrogen ion or proton without anything else. They just don't exist naked like that in water solution. Remember that water is a very polar material. There is a strong partial negative charge on the side of the oxygen atom and a strong partial negative charge on the hydrogen side. Any loose hydrogen ion, having a positive charge, would quickly find itself near one of the oxygens of a water molecule. At close range from the charge attraction, the hydrogen ion would find a pair (its choice of two pairs) of unshared electrons around the oxygen that would be capable of filling the its outer shell. Each hydrogen ion unites with a water molecule to produce a ***hydronium ion***, H_3O^+, the real species that acts as **acid**. The hydroxide ion in solution does not combine with a water molecule in any similar fashion. As we write reactions of acids and bases, it is usually most convenient to ignore the hydronium ion in favor of writing just a hydrogen ion.

Back to the beginning of Acids and Bases.

PROPERTIES OF ACIDS

For the properties of acids and bases we will use the Arrhenius definitions.

Acids release a hydrogen ion into water (aqueous) solution.

Acids neutralize bases in a neutralization reaction. An **acid** and a **base** combine to make a ***salt*** and water. A salt is any ionic compound that could be made with the anion of an **acid** and the cation of a **base**. The hydrogen ion of the **acid** and the hydroxide ion of the **base** unite to form water.

Acids corrode active metals. Even gold, the least active metal, is attacked by an **acid**, a mixture of acids called 'aqua regia,' or 'royal liquid.' When an **acid** reacts with a metal, it produces a compound with the cation of the metal and the anion of the **acid** and hydrogen gas.

Acids turn blue litmus to red. Litmus is one of a large number of organic compounds that change colors when a solution changes acidity at a particular point. Litmus is the oldest known pH indicator. It is red in **acid** and blue in **base**. The phrase, 'litmus test,' indicates that litmus has been around a long time in the English language. Litmus does not change color exactly at the neutral point between **acid** and **base**, but very close to it. Litmus is often impregnated onto paper to make 'litmus paper.'

Acids taste sour. TASTING LAB ACIDS IS NOT PERMITTED BY ANY SCHOOL. The word 'sauer' in German means **acid** and is pronounced almost exactly the same way as 'sour' in English. (Sauerkraut is sour cabbage, cabbage preserved in its own fermented lactic **acid**. http://www.bact.wisc.edu/lindquistjohn/324kraut.html) Stomach **acid** is hydrochloric **acid**. Although tasting stomach **acid** is not pleasant, it has the sour taste of **acid**. Acetic **acid** is the **acid** ingredient in vinegar. Citrus fruits such as lemons, grapefruit, oranges, and limes have citric **acid** in the juice. Sour milk, sour cream, yogurt, and cottage cheese have lactic **acid** from the fermentation of the sugar lactose.

Back to the beginning of Acids and Bases.

PROPERTIES OF BASES

Bases release a hydroxide ion into water solution. (Or, in the Lowry- Brønsted model, cause a hydroxide ion to be released into water solution by accepting a hydrogen ion in water.)

Bases neutralize acids in a neutralization reaction. The word reaction is:
Acid plus **base** makes water plus a salt. Symbolically, where 'Y' is the anion of **acid** 'HY,' and 'X' is the cation of **base** 'XOH,' and 'XY' is the salt in the product, the reaction is: $HY + XOH \rightarrow HOH + XY$

Bases denature protein. This accounts for the "slippery" feeling on hands when exposed to **base**. Strong bases that dissolve in water well, such as sodium or potassium lye are very dangerous because a great amount of the structural material of human beings is made of protein. Serious damage to flesh can be avoided by careful used of strong bases.

Bases turn red litmus to blue. This is not to say that litmus is the only **acid- base** indicator, but that it is likely the oldest one.

Bases taste bitter. There are very few food materials that are alkaline, but those that are taste bitter. It is even more important that care be taken in tasting bases. Again, NO SCHOOL PERMITS TASTING OF LAB CHEMICALS. Tasting of bases is more dangerous than tasting acids due to the property of stronger bases to denature protein.

Back to the beginning of Acids and Bases.

STRONG ACIDS AND STRONG BASES

The common acids that are almost one hundred percent ionized are:
HNO_3 - nitric **acid**
HCl - hydrochloric **acid**
H_2SO_4 - sulfuric **acid**
$HClO_4$ - perchloric **acid**
HBr - hydrobromic **acid**
HI - hydroiodic **acid**

The acids on this short list are called ***strong acids***, because the amount of **acid** quality of a solution depends upon the concentration of ionized hydrogens. You are not likely to see much HBr or HI in the lab because they are expensive. You are not likely to see perchloric **acid** because it can explode if not treated carefully. Other acids are incompletely ionized, existing mostly as the unionized form. Incompletely ionized acids are called ***weak acids***, because there is a smaller concentration of ionized hydrogens available in the solution. Do not confuse this terminology with the concentration of acids. The differences in concentration of the entire **acid** will be termed ***dilute*** or ***concentrated***. Muriatic **acid** is the name given to an industrial grade of hydrochloric **acid** that is often used in the finishing of concrete.

In the list of strong acids, sulfuric **acid** is the only one that is ***diprotic***, because it has two ionizable hydrogens per formula (or two mols of ionizable hydrogen per mol of **acid**). (Sulfuric **acid** ionizes in two steps. The first time a hydrogen ion splits off of the sulfuric **acid**, it acts like a strong **acid**. The second time a hydrogen splits away from the sulfate ion, it acts like a weak **acid**.) The other acids in the list are ***monoprotic***, having only one ionizable proton per formula. Phosphoric **acid**, H_3PO_4, is a weak **acid**. Phosphoric **acid** has three hydrogen ions available to ionize and lose as a proton, and so phosphoric **acid** is ***triprotic***. We call any **acid** with two or more ionizable hydrogens ***polyprotic***.

Likewise, there is a short list of strong bases, ones that completely ionize into hydroxide ions and a conjugate **acid**. All of the bases of Group I and Group II metals except for beryllium are strong bases. Lithium, rubidium and cesium hydroxides are not often used in the lab because they are expensive. The bases of Group II metals, magnesium, calcium, barium, and strontium are strong, but all of these bases have somewhat limited solubility. Magnesium hydroxide has a particularly small solubility. Potassium and sodium hydroxides both have the common name of ***lye***. Soda lye (NaOH) and potash lye (KOH) are common names to distinguish the two compounds.

LiOH - lithium hydroxide
NaOH - sodium hydroxide
KOH - potassium hydroxide
RbOH - rubidium hydroxide
CsOH - cesium hydroxide
$Mg(OH)_2$ - magnesium hydroxide
$Ca(OH)_2$ - calcium hydroxide
$Sr(OH)_2$ - strontium hydroxide
$Ba(OH)_2$ - barium hydroxide

The bases of Group I metals are all ***monobasic***. The bases of Group II metals are all ***dibasic***. Aluminum hydroxide is ***tribasic***. Any material with two or more ionizable hydroxyl groups would be called ***polybasic***. Most of the alkaline organic compounds (and some inorganic materials) have an amino group ($-NH_2$) rather than an ionizable hydroxyl group. The amino group attracts a proton (hydrogen ion) to become $(-NH_3)^+$. By the Lowry- Brønsted definition, an amino group definitely acts as a **base**, and the effect of removing hydrogen ions from water molecules is the same as adding hydroxide ions to the solution.

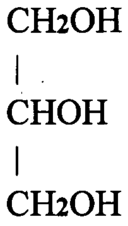
Memorize the strong acids and strong bases. Other acids or bases are weak.

Back to the beginning of Acids and Bases.

SOLUBILITY AND DISSOCIATION

Now, after considering the bases of Group II metals, is a fine time to think about acidity of a solution and the solubility of the compound. Calcium and magnesium hydroxides are used in ***antacids***, materials used to combat gastrointestinal acidity. How can that be if they are strong bases? In order to act as a **base**, the material must be dissolved. Almost all of these bases that are dissolved are dissociated, or ionized, but the low solubility of these bases makes them safe to swallow. An **acid** or **base** must first dissolve before it can dissociate (come apart) or ionize (become a pair of ions).

It is important to notice that just because a compound has a hydrogen or an OH group as a part of the structure does not mean that it can be an **acid** or a **base**. The hydrogens of methane, CH_4, are all very covalently attached to the carbon atom. Glycerin (or glycerol) has three OH groups in its structure.



$$\begin{array}{c} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}$$

These are alcoholic OH groups attached to a carbon atom. THE AVAILABILITY OF THE HYDROXIDE OR HYDROGEN AS AN ION DEPENDS UPON WHAT IT IS ATTACHED TO.

The chemical equation for the dissociation of nitric **acid** is:

$$HNO_3 \longrightarrow (NO_3)^- + H^+$$

For strong acids and strong bases the equation goes completely to the right. There is none of the original **acid** or **base**, but only the ions of the material unattached to each other in the water.

Back to the beginning of Acids and Bases.

OVERVIEW OF pH

pH is just a handy way to express how acidic or alkaline a water solution is. The pH of a solution is the negative log of the hydrogen ion concentration. The hydrogen ion concentration is inversely proportional to the hydroxide ion concentration, and the two of them multiplied together give the number 1 E-14. The table below shows the relationship among these measurements at the integers.

comments	$[H^+]$	pH	pOH	$[OH^-]$
very **base**	E-14	14	0	E-0

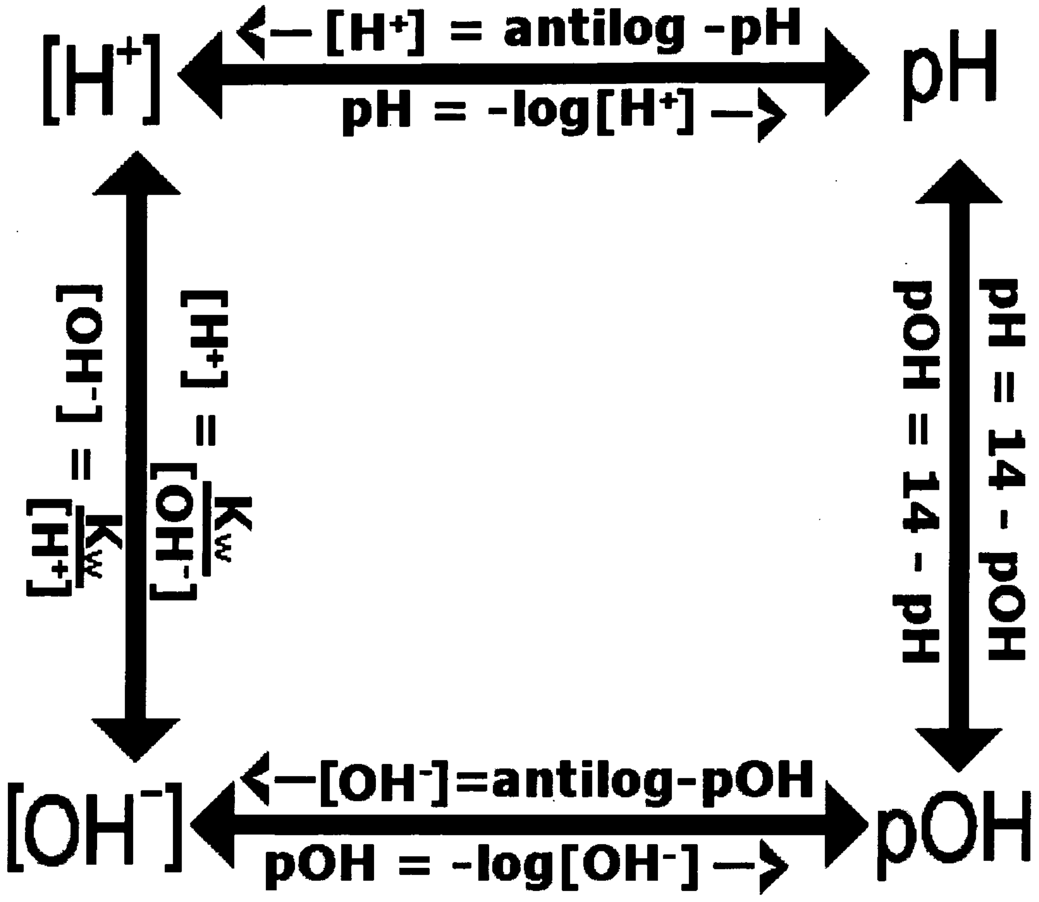
	E-13	13	1	E-1
base	E-12	12	2	E-2
	E-11	11	3	E-3
slightly **base**	E-10	10	4	E-4
	E-9	9	5	E-5
	E-8	8	6	E-6
NEUTRAL	E-7	7	7	E-7
	E-6	6	8	E-8
	E-5	5	9	E-9
slightly **acid**	E-4	4	10	E-10
	E-3	3	11	E-11
acid	E-2	2	12	E-12
	E-1	1	13	E-13
very **acid**	E-0	0	14	E-14

Back to the beginning of Acids and Bases.

THE pH BOX

The pH box is a similar sort of self-torture device to the temperature box. All four of the measurements are different ways to express exactly the same condition. The Kw of water, the dissociation constant, is a natural number amazingly close to 1 E-14. That is, when you multiply the hydrogen ion concentration $[H^+]$ by the hydroxide ion concentration $[(OH)^-]$ in pure water at near room temperature, the number is 1 E-14. If you know the $[(OH)^-]$, you know the $[H^+]$ and visa-versa. These two measurements are not the same scale, but they are two different measurements of the same thing. The pH is just the negative log of the $[H^+]$ and the pOH is just the negative log of the $[(OH)^-]$. The final leg of the box is the relationship between the pH and pOH, and that is the easiest one. pH + pOH = 14 because this is the exponential form of the Kw equation.

The hardest part of working the pH box is doing the "number crunching." The math is easier on a scientific calculator. Only a masochist would think about trying to do the computations by hand with a log table. Due to the large number of differences among hand calculators, there is a limit to the amount of help Chemtutor can give you in calculator work, but there are a few tips we can lend you.



Back to the beginning of Acids and Bases.

SCIENTIFIC CALCULATOR USE WITH pH BOX

Click for instructions on how to use a graphing calculator.

The calculator can be somewhat unfriendly in the math of the pH box. Let's take an example of using the box. The pH table before the pH box makes integer pH calculations easy, but the calculator is best used on non-integer pH's.

$[H^+] = 2.75$ E-6

Start with $[H^+] = 2.75$ E-6. Input 2 . 7 5 E +/- 6. To get the pH, punch 'log' (not *ln*, the natural log). The display shows -5.5607. The pH is the negative log, so it is 5.5607, rounded to 5.6, but you leave the -5.5607 on the display to keep going around the box.

pH = 5.5607

Punch + 1 4 = to add 14 to the negative pH. This will give you the pOH of 8.4393.

pOH = 8.4393

Punch the 'change sign' button, +/-. This changes 8.4393 to -8.4393. We need to get the antilog of -8.4393, and this function is not the same on many calculators. You may find a 2nd or an INV or shift or some other button to push before the log. My TI-30 SLR has INV on the button. Punch INV and then 'log' to get the $[OH^-]$. You may see a number like: 0.000,000,004 on your display. What did you do wrong? The correct answer is 3.6364 E-9.

$[OH^-]$ = 3.6364 E-9

Why is the display lying to you? It isn't. The numbers are the same, but your calculator showed you the long form (because it COULD) that is a large number of place-holding zeros and a single significant digit. The calculator actually has that number in its memory to eight or ten or sixteen digits, but it chose to only show you one significant digit. You can see the other digits on the display by multiplying by E6 (1 E6) or E9 (1 E9), but if you want to keep going around the box, you need to divide by the same number (with as many significant digits as you can) to get the $[OH^-]$ back. Or, you could store the $[OH^-]$ number before you take a look at it. Your calculator should have a button marked STO or M+ or M1 that will store your number into memory. Do that before you peek at the number. To get back that stored number, you punch RCL or M-. To get back to the original $[H^+]$, punch in: 1 E +/- 1 4 ÷ RCL = . You should see your good old $[H^+]$ of 2.75 E-6 on the display.

$[H^+]$ = 2.75 E-6

Now for practice, go around the pH box the other way.

The rules are:

- To get pH from $[H^+]$ or to get pOH from $[OH^-]$, use the negative of the log.
- To go from $[OH^-]$ to pOH or from $[H^+]$ to pH, use antilog of the negative number.
- To go from $[H^+]$ to $[OH^-]$ or back, first put in the Kw, 1E-14 and divide by the one you are leaving.

To go from pH to pOH or back, subtract the number you have from 14.

Proficiency in pH box calculations requires practice. There is no Chemtutor Quickquiz on the pH box because you can make your own exercises and check your answers by coming back to the same number. You will use the pH box calculations in many problems in this **acid- base** section.

Back to the beginning of Acids and Bases.

WEAK ACIDS AND WEAK BASES

We can write the chemical equation for the dissociation of a weak **acid,** using 'A^-' to represent the conjugate **base**, as;

$$HA \rightarrow A^- + H^+$$

And, similarly, we can write the chemical equation for the dissociation of a weak **base,** using 'X^+' to represent the conjugate **acid,** as;

$$XOH \rightarrow OH^- + X^+$$

The equilibrium expression for the dissociation of a weak **acid** is;

$$k_A = \frac{[H^+][A^-]}{[HA]}$$

In language, the equilibrium expression reads; "The dissociation constant of an **acid** is equal to the concentration of hydrogen ions times the concentration of the conjugate **base** of the **acid** divided by the concentration of un-ionized **acid.**"

$$k_B = \frac{[X^+][OH^-]}{[XOH]}$$

Similarly, the equilibrium expression for a weak **base** reads: "The dissociation constant of a **base** equals concentration of hydroxide ions times concentration of conjugate **acid** divided by the concentration of un-ionized **base.**"

The k_A of an **acid** or the k_B of a **base** are properties of that **acid** or **base** at the given temperature. The temperature at which these dissociation constants are listed is usually near room temperature.

The equilibrium expressions are for monoprotic acids or monobasic alkalis or the first dissociation of a polyprotic **acid** or a polybasic alkali. Phosphoric **acid** (H_3PO_4) is a good example of a polyprotic **acid**. When completely ionized, a mol of phosphoric **acid** will give three hydrogen ions and a phosphate ion, but the hydrogen ions come off one at a time at different pH's and with different k_A's.

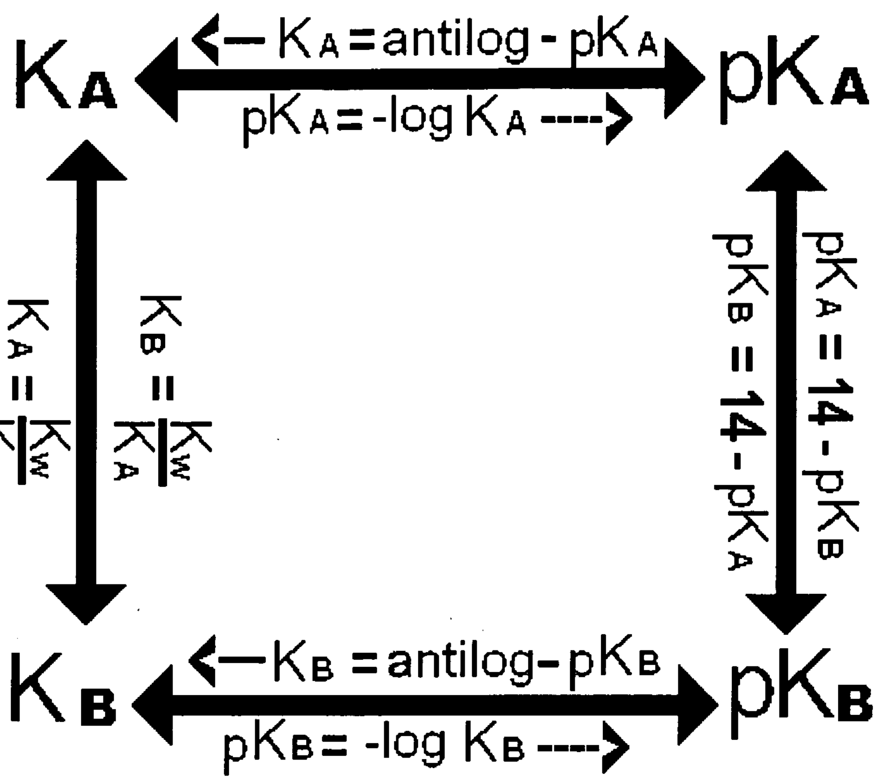
$H_3PO_4 \rightarrow (H_2PO_4)^- + H^+$	first ionization	$k_A = 6.92$ E-3
$(H_2PO_4)^- \rightarrow (HPO_4)^{2-} + H^+$	second ionizaton	$k_A = 6.17$ E-8
$(HPO_4)^{2-} \rightarrow (PO_4)^{3-} + H^+$	third ionization	$k_A = 2.09$ E-12

Any **acid** with more than one ionizable hydrogen or any **base** with more than one ionizable hydroxide will usually separate stepwise as phosphoric **acid**.

Back to the beginning of Acids and Bases.

THE pKA BOX

The pKA of an **acid** is a very useful number, as you will see in the math below. The pKA is the negative log of the kA, the pKB is the negative log of the kB, and the pKA plus the pKB equal fourteen. The kA box is the same as the pH box, but substitute kA for $[H^+]$, pKA for pH, kB for $[OH^-]$, and pKB for pOH.



Back to the beginning of Acids and Bases.

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pH OF STRONG ACIDS AND BASES

Strong acids and bases have all of the dissolved material completely ionized. The concentration of a monoprotic **acid** is equal to the concentration of hydrogen ion. The concentration of a monobasic alkali is equal to the concentration of hydroxide ion. The actual concentration of hydrogen ion (or hydroxide ion) from pure water is on the order of concentration of E-7 Molar, so any concentration of a strong **acid** or **base** over E-5 Molar completely swamps the comparatively tiny amount of ion from the ionization of water.

What is the pH of 0.0850 M HNO_3? Nitric **acid** is a monoprotic strong **acid**. $[HNO_3] = [H^+]$ and pH = - log $[H^+]$, so, pH = - log (0.085) = 1.07 Only one step on the pH box.

What is the pH of 0.00765 KOH? Potassium hydroxide is a monobasic strong **base**. $[KOH] = [OH^-]$ and pOH = - log $[OH^-]$ and pH = 14 - pOH Or you could go around the pH box the other way. The pOH = 2.12 and pH = 11.88.

Back to the beginning of Acids and Bases.

WEAK ACIDS

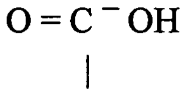
The following tables are published here for your convenience in working problems and seeing examples of weak acids and bases. There is no need for you to memorize the names, formulas, or numbers associated with these materials.

ACID	**FORMULA**	**k_A**	**pk_A**
acetic **acid**	$H(C_2H_3O_2)$	1.74 E-5	4.76
ascorbic **acid** (1)	$H_2(C_6H_6O_6)$	7.94 E-5	4.10
ascorbic **acid** (2)	$(HC_6H_6O_6)^-$	1.62 E-12	11.79
boric **acid** (1)	H_3BO_3	5.37 E-10	9.27
boric **acid** (2)	$(H_2BO_3)^-$	1.8 E-13	12.7
boric **acid** (3)	$(HBO_3)^{=}$	1.6 E-14	13.8
butanoic **acid**	$H(C_4H_7O_2)$	1.48 E-5	4.83
carbonic **acid** (1)	H_2CO_3	4.47 E-7	6.35
carbonic **acid** (2)	$(HCO_3)^-$	4.68 E-11	10.33
chromic **acid** (1)	H_2CrO_4	1.82 E-1	0.74
chromic **acid** (2)	$(HCrO_4)^-$	3.24 E-7	6.49
citric **acid** (1)	$H_3(C_6H_5O_7)$	7.24 E-4	3.14
citric **acid** (2)	$(H_2C_6H_5O_7)^-$	1.70 E-5	4.77
citric **acid** (3)	$(HC_6H_5O_7)^{=}$	4.07 E-7	6.39
formic **acid**	$H(CHO_2)$	1.78 E-4	3.75
heptanoic **acid**	$H(C_7H_{13}O_2)$	1.29 E-5	4.89
hexanoic **acid**	$H(C_6H_{11}O_2)$	1.41 E-5	4.84
hydrocyanic **acid**	HCN	6.17 E-10	9.21
hydrofluoric **acid**	HF	6.31 E-4	3.20
lactic **acid**	$H(C_3H_5O_3)$	8.32 E-4	3.08
nitrous **acid**	HNO_2	5.62 E-4	3.25
octanoic **acid**	$H(C_8H_{15}O_2)$	1.29 E-4	4.89
oxalic **acid** (1)	$H_2(C_2O_4)$	5.89 E-2	1.23
oxalic **acid** (2)	$(HC_2O_4)^-$	6.46 E-5	4.19
pentanoic **acid**	$H(C_5H_9O_2)$	3.31 E-5	4.84
phosphoric **acid** (1)	H_3PO_4	6.92 E-3	2.16
phosphoric **acid** (2)	$(H_2PO_4)^-$	6.17 E-8	7.21
phosphoric **acid** (3)	$(HPO_4)^{=}$	2.09 E-12	12.32
propanoic **acid**	$H(C_3H_5O_2)$	1.38 E-5	4.86
sulfuric **acid** (2)	$(HSO_4)-$	1.05 E-2	1.98
sulfurous **acid** (1)	H_2SO_3	1.41 E-2	1.85

sulfurous **acid** (2)	$(HSO_3)^-$	6.31 E-8	7.20
uric **acid**	$H(C_5H_3N_4O_3)$	1.29 E-4	3.89

The organic acids in the table above have been written as **acid** with conjugate **base** as different from the standard notation. Notice that sulfuric **acid's** first ionization is a strong **acid**, so it is not on this table. Ascorbic **acid** is vitamin C. Some of the acids in the table are not very soluble, such as uric **acid**.

An organic **acid** usually has a - COOH group in it. The shape of that group is more like;



$$O = C - OH$$

There is a double bond between the carbon and the single oxygen. There is a single bond with an alcohol group (-OH). There is one more bond to the central carbon that is usually attached to another carbon. The hydrogen of the alcohol group is the one that has a tendency to ionize away from the group, leaving a $(-COO)^-$ ion at the end of the **acid**.

Notice the set of organic acids that begin with formic **acid**. Formic **acid** has a hydrogen attached to the carbon in the organic **acid** group. Acetic **acid** has a $(-CH_3)$ group attached to the carbon in the organic **acid** group. The line of carbons becomes longer for the acids that follow. There are no branched chains of carbon atoms or any double or triple bonds between the carbons of the organic acids on this list.

The physiological organic acids (the organic acids that are found in living things) all have even numbers of carbons. Hexanoic, octanoic, and decanoic (C-6, C-8, and C-10 acids) are named for goats, which will give you an idea of the smell of those compounds.

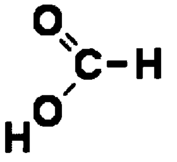
The name most used for the organic **acid** is in bold print in this table.

SYSTEM NAME	**NUMBER OF CARBONS**	**COMMON NAME**
methanoic **acid**	1 carbon	**formic acid**
ethanoic **acid**	2 carbons	**acetic acid**
propanoic acid	3 carbons	**propionic acid**
butanoic acid	4 carbons	**butyric acid**
pentanoic acid	5 carbons	valeric **acid**
hexanoic acid	6 carbons	caproic **acid**
heptanoic acid	7 carbons	enanthic **acid**
octanoic acid	8 carbons	caprylic **acid**
nonanoic acid	9 carbons	pelargonic **acid**
decanoic acid	10 carbons	capric **acid**

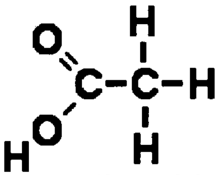
THE FOLLOWING ARE 'FATTY ACIDS'

dodecanoic acid	12 carbons	**lauric acid**
tetradecanoic **acid**	14 carbons	**myristic acid**
hexadecanoic **acid**	16 carbons	**palmitic acid**
octadecanoic **acid**	18 carbons	**stearic acid**
eicosanoic **acid**	20 carbons	**arachidic**
tetracosanoic **acid**	24 carbons	**lignoceric**

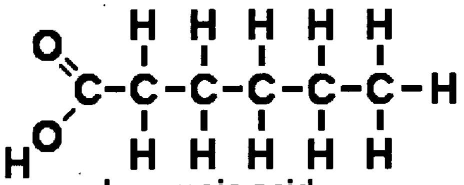
Below are some of the molecular formulas of some of the organic acids in the stick and symbol form. The ionizable hydrogen is in blue.



formic acid



acetic acid



hexanoic acid

Organic acids with straight carbon even- number chains of twelve to twenty- four are called ***fatty acids***. See soap for more on fatty acids. You can see that the pK$_A$'s are very close for all of the similar organic acids. Formic and acetic acids are water soluble. As the carbon chain increases in length, the molecule becomes less and less water soluble. Beginning with propanoic **acid**, even as the number of carbons increase, the pK$_A$'s do not change much.

Back to the beginning of Acids and Bases.

WEAK BASES

Many materials are weak bases due to the presence of an amino group ($-NH_2$) attached to an organic compound. Nitrogen has five electrons in the outside shell. The three solo electrons can participate in (covalent) bonds to the nitrogen. The unshared pair of electrons can be donated by the nitrogen atom to constitute a complete covalent bond with a material that lacks a pair of electrons. The Lewis definition most clearly shows that the donor of the pair of electrons (the N atom) is a **base** and anything that attaches to the nitrogen by accepting a position of covalent attachment to the nitrogen is an **acid**.

BASE	**FORMULA**	**k$_B$**	**pk$_B$**
alanine	$C_3H_5O_2NH_2$	7.41 E-5	4.13
ammonia (water)	NH_3 (NH_4OH)	1.78 E-5	4.75
dimethylamine	$(CH_3)_2NH$	4.79 E-4	3.32
ethylamine	$C_2H_5NH_2$	5.01 E-4	3.30
glycine	$C_2H_3O_2NH_2$	6.03 E-5	4.22

hydrazine	N_2H_4	1.26 E-6	5.90
methylamine	CH_3NH_2	4.27 E-4	3.37
trimethylamine	$(CH_3)_3N$	6.31 E-5	4.20

Alanine and glycine are amino acids, two of the twenty- or- so types of building blocks of protein. Each amino **acid** has both an amino (**base**) end and an **acid** end. Only the amino end (the **base** side) numbers are listed.

Back to the beginning of Acids and Bases.

THE 5% RULE

The measurement and calculation of pH is not as accurate as some other of the chemical measures due to differences in temperature, other ions present, purity of solutes, concentration changes due to evaporation, etc. Measurement of pH in medicine, for instance must be at 37 degrees Celsius. There may be machines that claim to measure pH to hundredths or thousandths of a pH unit, but the standard that calibrates the machine may be off a little. A change of five percent in the hydrogen ion concentration will not change the pH more than a few hundredths of a pH unit. You try it on the calculator. Enter a number, say 0.001 and punch log. Now punch a number 95% or 105% of the first number (in this case, 0.00105 or 0.00095) and punch log. How different is the pH? Our answers in pH are going to be to the nearest tenth of a pH unit, so the hydrogen ion concentration needs to be only within 5% of an accurate number. This idea is the 'five percent rule.'

You may remember we mentioned that the concentration of a strong **acid** is equal to the hydrogen ion concentration. That is not exactly so. In any water solution of an **acid** there is another source of hydrogen ions, the ***water***. Water alone has a hydrogen ion concentration of E-7 Molar. Let's say you have a a E-5 M HCl solution, the contribution of the water is only a hundredth of the amount of hydrogen ion from the **acid** at the first approximation. You could approximate the real hydrogen ion concentration better by finding the hydroxide ion concentration of a solution with E-5 hydrogen ion concentration and then finding the added hydrogen ion concentration due to the dissociation of water from that. The total hydrogen ion concentration will be even further from having any significant contribution of hydrogen ion from the ionization of water. Does the ionization of water have an significance in this case? Of course not. There is much less than five percent difference difference between the two numbers. Here is an obvious situation where you can use the simpler approximation of the hydrogen ion concentration to find the pH. There are some times when the simpler approximation is not accurate enough. There are some times when you may be in doubt and would need to work it BOTH ways to show whether you can use a simplified method.

Another way to state the five percent rule is: If you have a simplified way of solving for the hydrogen ion concentration that would give you an answer you can show would be within 5% of the more accurate way of calculating it, you can use the simpler method.

Back to the beginning of Acids and Bases.

pH OF WEAK ACIDS AND BASES

Weak acids and bases do not ionize very much, so the $[H^+]$ or $[(OH)^-]$ must be calculated by the equilibrium expression.

$$k_A = \frac{[H^+][A^-]}{[HA]}$$

This would be easy to know exactly, except that the [HA] is not always equal to the concentration of solute that actually went into the solution. The more accurate way to express the equilibrium expression would be to include in the denominator the idea that the [HA] is really the concentration of solute originally put into solution minus the amount of that solute that ionized. We could represent the amount that ionized by either the $[A^-]$ or the $[H^+]$, so the denominator should be either $[HA] - [A^-]$ or $[HA] - [H^+]$. Let's use the second option for alternative denominator because we want to solve for the hydrogen ion concentration. By the 5% rule, $[HA] = [HA] - [H^+]$ only if the hydrogen ion concentration is less than five percent of the total solute concentration. This is the case for most weak acids. The only exceptions are when the strongest of the weak acids are in the most dilute solutions.

If you have a stronger weak **acid** (one with a high k_A), you should check to see if the $[H^+]$ is near 5% of the total solute concentration. If it is, you will have to use the alternative denominator in the equation and solve it for $[H^+]$ by quadratic equation.

**start with the ionization equilibrium expression
with the alternative denominator**

$$k_A = \frac{[H^+][A^-]}{[HA]-[H^+]}$$

**simplify by combining $[A^-]$ and $[H^+]$ and
then multiply by the denominator to get:**

$$k_A[HA] - k_A[H^+] = [H^+]^2$$

**and, eventually, you get an expression that
looks like a real quadratic equation in $[H^+]$ that
can be solved by the quadratic formula.**

$$[H^+]^2 + k_A[H^+] - k_A[HA] = 0$$

Heaven forfend the need for using a quadratic equation. (I would rather kiss a BIG alligator.) It's a lot easier if the $[H^+]$ is less than five percent of the [HA].

If there is only water and a weak **acid** in the solution, each mol of the **acid** dissociates into only one mol of hydrogen ions and only one mol of conjugate **base** ions. $[H^+] = [A^-]$! So;

$$k_A = \frac{[H^+]^2}{[HA]}$$

and solving for $[H^+]^2$,

$$[H^+]^2 = k_A [HA]$$

then taking the square root of both sides, you have $[H^+]$.

$$[H^+] = \sqrt{k_A [HA]}$$

Once you have the hydrogen ion concentration, you can go anywhere on the pH box.

The same idea goes for a weak **base** as the only material in water solution. Start with the equilibrium expression and the conjugate **acid** ion being equal to the hydroxide concentration. You will start with the **base** equilibrium expression:

$$k_B = \frac{[X^+][OH^-]}{[XOH]}$$

and solve for $[OH^-]$ to get;

$$[OH^-] = \sqrt{k_B [XOH]}$$

And it's back to the pH box for anything else you need.

Back to the beginning of Acids and Bases.

BUFFERS AND pH OF BUFFERS

A **buffer** is a solution that resists changes in pH. A **buffer** is made with a weak **acid** and a soluble salt containing the conjugate **base** of the weak **acid** or a weak **base** and a soluble salt containing the conjugate **acid** of the weak **base**. Some examples of **buffer** material pairs are:

acetic **acid** and sodium acetate,

phosphoric **acid** and potassium phosphate,

oxalic **acid** and lithium oxalate

carbonic **acid** and sodium carbonate,

or ammonium hydroxide and ammonium nitrate.

A **buffer** is most effective in solutions of pH at or close to the pKA of the weak **acid**. (Or solutions of pOH at or close to the pKB of the weak **base**.) The most buffering capacity is available when the concentration of weak **acid** or **base** is close to the concentration of the conjugate ion and when the concentration of both is greatest.

Thinking backwards, if you need a **buffer** at a particular pH lower than seven, chose the weak **acid** that has a pKA close to that pH and a conjugate **base** to go with it.

We can start again from the equilibrium expression of the ionization of a weak **acid** or a weak **base**;

$$k_A = \frac{[H^+][A^-]}{[HA]}$$

In **buffer** solutions the concentration of hydrogen ion is **not** equal to the concentration of conjugate ion. The concentration of conjugate ion from the dissociation of the **acid** is negligible, so we can calculate as if all the conjugate ion comes from the salt. If the soluble salt has only one mol of conjugate ion per mol of salt, the concentration of conjugate ion is the same as the concentration of salt.

The entrance to the pH box again is the hydrogen ion concentration. Solve for the hydrogen ion concentration if you need it, the pH of the solution, the pOH, or the hydroxide ion concentration.

$$[H^+] = \frac{k_A[HA]}{[A^-]}$$

which is the same as:

$$[H^+] = (k_A)\left(\frac{1}{[A^-]}\right)([HA])$$

phosphate-buffer saline
Ringer's lactate
Mops
Tris
bis-tris buffer
sodium acetate

The Henderson-Hasselbalch (H-H) equation can be somewhat confusing, but it is nothing more than the negative log of the the equation above, the equilibrium expression solved for the hydrogen ion concentration. If you know the equilibrium equation, know how to solve the equilibrium equation for the hydrogen ion concentration, and know how to convert the hydrogen ion concentration to the pH, you have it licked. If you really need the H-H equation for a test, it is best to make sure you are getting it right by deriving it from the equilibrium expression.

$$-\log[H^+] = pH$$

$$-\log k_A = pK_A$$

$$-\log(1/[A^-]) = +\log[A^-]$$

$$-\log([HA]) = -\log[HA]$$

Component-by-component take the negative log of the equilibrium expression and change the multiplication to addition. (They are logs now.) You get:

$pH = pK_A + \log[A^-] - \log[HA]$, which is the same as;

$pH = pK_A - \log\left([HA]/[A^-]\right)$, the usual way you see the H-H equation.

There are four perfectly correct ways to write the H-H equation. They are:

$$pH = pk_A - \log\frac{[HA]}{[A^-]}$$

or

$$pH = pk_A + \log\frac{[A^-]}{[HA]}$$

or

$$pOH = pk_B + \log\frac{\left[\text{conjugate cation}\right]}{[\text{base}]}$$

or

$$pOH = pk_B - \log\frac{[\text{base}]}{\left[\text{conjugate cation}\right]}$$

An ***equimolar*** **buffer** is one in which the concentration of the weak **acid** (or **base**) is the same as the concentration of the conjugate ion. This may not seem particularly significant to you, but there are several important ideas that can be easily seen from it. Start with the ionization equilibrium expression and cancel the [HA] with the [A⁻]. This shows that in an equimolar **buffer** $k_A = [H^+]$.

$$k_A = \frac{[H^+]\cancel{[A^-]}}{\cancel{[HA]}}$$

if [HA] = [A$^-$]

$$k_A = [H^+]$$

This shows how a **buffer** works. As **acid** or **base** is added to a **buffer** solution, the **buffer** equilibrium will trade off [HA] with [A$^-$] to come to a new equilibrium. When that happens, there will be a much smaller change in the hydrogen ion concentration than if the **acid** or **base** were added to an unbuffered solution.

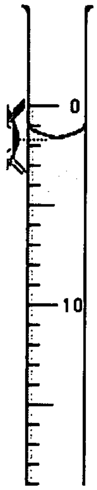
Now let's do a similar trick with the H-H equation. If [HA] = [A$^-$], the term [HA]/[A$^-$] = 1 and log 1 = 0, so pH = pKA.

$$pH = pK_A - \log \frac{\cancel{[HA]}}{\cancel{[A^-]}}$$

$$pH = pK_A$$

This indicates that in an equimolar **buffer** the pH = pKA and that the RATIO of the [HA] to the [A$^-$] will determine the pH of the solution. The further the ratio gets from one to one, the further the pH gets from the pKA. The **buffer** has its greatest buffering power at the pKA of the weak **acid** (or **base**). The higher the concentration of both the weak **acid** and its conjugate ion, the more buffering power is available.

Back to the beginning of Acids and Bases.



TITRATION

The word "titration" rhymes with "***tight nation***," and refers to a commonly used method of (usually) finding the concentration of an unknown liquid by comparing it with a known liquid. An **acid-base** titration is good to consider when learning the method, but there are more uses for the technique. The measure of oxalate ion using potassium permanganate in a warm **acid** environment is a good example of a redox titration. The Mohr titration is a determination of chloride concentration using known silver nitrate solution and sodium dichromate an indicator.

A measured amount of the unknown material in a flask with indicator is usually combined with the known material from a buret (rhymes with "sure bet"). The buret is marked with the volume of liquid by a scale with zero on top and (usually) fifty milliliters on the bottom. The buret has some type of valve at the bottom that can dispense the contained liquid.

It is not necessary to start the titration with the known liquid level in the buret at the zero mark, but the level must be within the portion of the buret that is marked. The buret on the left shows about 1.8 ml of the yellow liquid in it. Most laboratory burets can be read to an accuracy of one hundredth of a milliliter. (The drawing on the left is a bit crude. Most burets show the ten divisions of a milliliter and you can interpolate between the marks.) One reads the buret by getting at eye level to the bottom of the meniscus (curve in the liquid) and comparing the bottom of the meniscus to the marks on the glass. A reading of the buret is taken before and at the end of the titration. The amount of know-concentration liquid used is the difference of the beginning and ending buret reading.

The ***endpoint*** of the titration is usually shown by some type of indicator. A ***pH indicator*** is a material, usually an orgainc dye, that is one color above a characteristic pH and another color below that pH. There are many materials that can serve as pH indicators, each with its own ph range at which it changes color. Some have more than one color change at distinct pH's. Litmus and phenolphthalein are common pH indicators. Litmus is red in **acid** (below pH 4.7) and blue in **base** (above pH 8.1). Phenolphthalein (The second 'ph' is silent and the 'a' and both 'e's are long, if that is any help.) is clear in **acid** (below pH 8.4) and pink- purple in **base** (above pH 9.9). These ranges may seem large, but near the ***equivalence point***, the point at which the materials are equal, there is a large change in pH. The equivalence point may not occur at pH 7, neutral pH, so the appropriate pH indicator must be chosen for the type of **acid** and **base** being titrated.

The volume of the material of unknown concentration is known by how much is put into the reaction vessel. The concentration of the standard is known, and its volume is known from the measurement of liquid used in the titration.

If you have a monobasic **base** and a monoprotic **acid**, you can simplify the formula for titration to: if C_A = the concentration of the **acid** and C_B = the concentration of the **base** and V_A = the volume of **acid** solution and V_B = the volume of **base**, then,

$$C_A V_A = C_B V_B$$

Back to the beginning of Acids and Bases.

SALTS

A ***salt*** is the combination of an anion (- ion) and a cation (a + ion). Another way to think of a salt is the combination of the anion of a certain **acid** combined with the cation of a certain **base**. The neutralization of potassium hydroxide with hydrochloric **acid** produces water and the salt, potassium chloride. In a solid salt, the ions are held together by the difference in charge. Solid salts usually make crystals, sometimes including specific molar amounts of water, called ***water of hydration*** into the crystal. If a salt dissolves in water solution, it usually dissociates (comes apart) into the anions and cations that make up the salt.

Salts dissolved in water may not be at neutral pH. Table salt, NaCl, has a neutral pH in water, but baking soda, $NaHCO_3$ is very alkaline when dissolved in water. Take a teaspoonful of baking soda on your hand, wet it, and completely wash your hands with it. (Baking soda is a really fine material for cleaning hands!) There is the hint of the slipperiness of bases on your hands that had to come from the baking soda.

How can you predict the pH of a salt dissolved in water? The actual pH will depend on the type of anion and cation, the solubility of the salt, the temperature of the solution, and concentration of the salt if less than saturated. salt. Here are the general rules:

- Salts made of the anion of a strong **acid** and the cation of a strong **base** will be neutral salts, that is, the water solution with this salt will have a pH of seven. (example - sodium chloride)

- Salts made of the anion of a strong **acid** and the cation of a ***weak*** **base** will be **acid** salts, that is, the water solution with this salt will have a pH of less than seven. (example - ammonium chloride)

- Salts made of the anion of a ***weak*** **acid** and a strong **base** will be an alkali salt. The pH of the solution will be over seven. (example - sodium bicarbonate)

- It can be a bit more difficult to tell the pH of a salt solution if the salt is made of the anion of a weak **acid** and the cation of a weak **base.** Usually, the main determining factor is whether the weak **acid** is weaker than the weak **base,** but that is not always the case. For the purpose of the problems in the review section, you may say that the pH of a 'weak-weak' salt is indeterminate.

Back to the beginning of Acids and Bases.

TITRATION AND pH PROBLEMS

THE FOLLOWING SALTS IN WATER SOLUTION WILL HAVE A pH OF 7, -7(less than 7), +7 (more than 7), OR INDETERMINATE (I). FOR EACH PREDICT THE pH OF THE SOLUTION. Explanations

1. Na_2CO_3 2. $FeCl_3$ 3. KNO_3 4. $NH_4C_2H_3O_2$

5. $ZnSO_4$ 6. $Ba(NO_3)_2$ 7. RbF 8. $CaBr_2$

FIND THE pH OF THE FOLLOWING SOLUTIONS. Find kA's, pKA's, kB's, and pKB's on the tables above.

9. 0.0115 M HCl 10. 0.0815 M NaOH 11. 0.00372 M $Ba(OH)_2$

12. 0.12 M $HC_2H_3O_2$ 13. 1.35 E-5 H_3BO_3 14. 0.255 M NH_4OH

15. 0.578 M H_3PO_4 16. 0.16 M HCl and 0.072 M phosphoric **acid**.

17. 1.25 M acetic **acid** and 0.75 M potassium acetate.

18. 0.788 M lactic **acid** and 1.27 M calcium lactate.

19. 0.590 M ammonium hydroxide and 1.57 M ammonium chloride.

20. Explain how to make 5 L of 0.15 M acetic **acid**-sodium acetate **buffer** at pH 5.00 if you have 1.00 Molar acetic **acid** and crystaline sodium acetate.

FOLLOWING ARE TITRATION PROBLEMS. ASSUME THAT THE pH INDICATOR WILL BE THE RIGHT ONE TO BALANCE THE AMOUNT OF **ACID** AND **BASE**. SOME OF THE TITRATIONS ARE NOT **ACID** - **BASE** TITRATIONS. AGAIN ASSUME THERE IS AN INDICATOR THAT WILL TELL WHEN MOLAR AMOUNTS ARE MATCHED.

21. 23.45 mL of 0.275 M sodium hydroxide was used to titrate against mL of acetic **acid**. What was the concentration in M of acetic **acid**?

22. 17.05 mL of 0.247 M barium hydroxide was used to titrate against 10 mL of nitric **acid**. What was the concentration in M of nitric **acid**?

23. 35.79 mL of 0.275 M sodium hydroxide was used to titrate against 15 mL of sulfuric **acid**. What was the concentration in M of sulfuric **acid**?

24. 24.92 mL of 0.00199 M silver nitrate was used to titrate against 5 mL of sodium chloride solution. What was the concentration of NaCl?

ANSWERS TO PROBLEMS

1. +7 2. -7 3. 7 4. I 5. -7
6. 7 7. +7 8. 7 9. 1.9 10. 12.9
11. 11.9 12. 2.8 13. 6.8 14. 11.3 15. 1.2
16. 0.8 17. 4.5 18. 3.6 19. 8.8
20. Weigh 39.1 g of sodium acetate, measure 274 ml of the 1.00 Molar acetic acid and place into a 5 liter volumetric flask. Dissolve, then fill the volumetric flask to the line with distilled water and mix.
21. 1.29 M <22. 0.842 M> 23. 0.328 M 24. 9.92 E-3 M

Heuristics
Numbers and Math
Units and Measures
Atomic Structure
Elements
Periodic Table
States of Matter
Compounds
Reactions
Mols, Stoichiometry, and Percents
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BUFFER SOLUTIONS

This page describes simple acidic and alkaline **buffer** solutions and explains how they work.

What is a buffer solution?

Definition

A **buffer** solution is one which resists changes in pH when small quantities of an acid or an alkali are added to it.

Acidic buffer solutions

An acidic **buffer** solution is simply one which has a pH less than 7. Acidic **buffer** solutions are commonly made from a weak acid and one of its salts - often a sodium salt.

A common example would be a mixture of ethanoic acid and sodium ethanoate in solution. In this case, if the solution contained equal molar concentrations of both the acid and the salt, it would have a pH of 4.76. It wouldn't matter what the concentrations were, as long as they were the same.

You can change the pH of the **buffer** solution by changing the ratio of acid to salt, or by choosing a different acid and one of its salts.

Note: If you need to know about calculations involving **buffer** solutions, you may be interest in my **chemistry** calculations book.

Alkaline buffer solutions

An alkaline **buffer** solution has a pH greater than 7. Alkaline **buffer** solutions are commonly made from a weak base and one of its salts.

A frequently used example is a mixture of ammonia solution and ammonium chloride solution. If these were mixed in equal molar proportions, the solution would have a pH of 9.25. Again, it doesn't matter what concentrations you choose as long as they are the same.

How do buffer solutions work?

A **buffer** solution has to contain things which will remove any hydrogen ions or hydroxide ions that you might add to it - otherwise the pH will change. Acidic and alkaline **buffer** solutions achieve this in different ways.

Acidic buffer solutions

We'll take a mixture of ethanoic acid and sodium ethanoate as typical.

Ethanoic acid is a weak acid, and the position of this equilibrium will be well to the left:

$$CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$$

Adding sodium ethanoate to this adds lots of extra ethanoate ions. According to Le Chatelier's Principle, that will tip the position of the equilibrium even further to the left.

Note: If you don't understand Le Chatelier's Principle, follow this link before you go any further, and make sure that you understand about the effect of changes of concentration on the position of equilibrium.

Use the BACK button on your browser to return to this page.

The solution will therefore contain these important things:

- lots of un-ionised ethanoic acid;
- lots of ethanoate ions from the sodium ethanoate;
- enough hydrogen ions to make the solution acidic.

Other things (like water and sodium ions) which are present aren't important to the argument.

Adding an acid to this buffer solution

The **buffer** solution must remove most of the new hydrogen ions otherwise the pH would drop markedly.

Hydrogen ions combine with the ethanoate ions to make ethanoic acid. Although the reaction is reversible, since the ethanoic acid is a weak acid, most of the new hydrogen ions are removed in this way.

$$CH_3COO^-_{(aq)} + H^+_{(aq)} \rightleftharpoons CH_3COOH_{(aq)}$$

Since most of the new hydrogen ions are removed, the pH won't change very much - but because of the equilibria involved, it *will* fall a little bit.

Adding an alkali to this buffer solution

Alkaline solutions contain hydroxide ions and the **buffer** solution removes most of these.

This time the situation is a bit more complicated because there are *two* processes which can remove hydroxide ions.

Removal by reacting with ethanoic acid

The most likely acidic substance which a hydroxide ion is going to collide with is an ethanoic acid molecule. They will react to form ethanoate ions and water.

$$CH_3COOH_{(aq)} + OH^-_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H_2O_{(l)}$$

Note: You might be surprised to find this written as a slightly reversible reaction. Because ethanoic acid is a weak acid, its conjugate base (the ethanoate ion) is fairly good at picking up hydrogen ions again to re-form the acid. It can get these from the water molecules. You may well find this reaction written as one-way, but to be fussy about it, it is actually reversible!

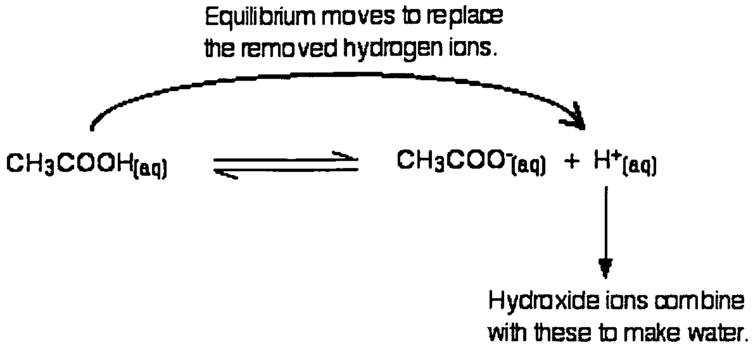
Because most of the new hydroxide ions are removed, the pH doesn't increase very much.

Removal of the hydroxide ions by reacting with hydrogen ions

Remember that there are some hydrogen ions present from the ionisation of the ethanoic acid.

$$CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$$

Hydroxide ions can combine with these to make water. As soon as this happens, the equilibrium tips to replace them. This keeps on happening until most of the hydroxide ions are removed.


Equilibrium moves to replace the removed hydrogen ions.
Hydroxide ions combine with these to make water.

$$CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$$

Again, because you have equilibria involved, not *all* of the hydroxide ions are removed - just most of them. The water formed re-ionises to a very small extent to give a few hydrogen ions and hydroxide ions.

Alkaline buffer solutions

We'll take a mixture of ammonia and ammonium chloride solutions as typical.

Ammonia is a weak base, and the position of this equilibrium will be well to the left:

$$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)}$$

Adding ammonium chloride to this adds lots of extra ammonium ions. According to Le Chatelier's Principle, that will tip the position of the equilibrium even further to the left.

The solution will therefore contain these important things:

- lots of unreacted ammonia;
- lots of ammonium ions from the ammonium chloride;
- enough hydroxide ions to make the solution alkaline.

Other things (like water and chloride ions) which are present aren't important to the argument.

Adding an acid to this buffer solution

There are *two* processes which can remove the hydrogen ions that you are adding.

Removal by reacting with ammonia

The most likely basic substance which a hydrogen ion is going to collide with is an ammonia molecule. They will react to form ammonium ions.

$$NH_{3(aq)} + H^+_{(aq)} \rightleftharpoons NH_4^+{}_{(aq)}$$

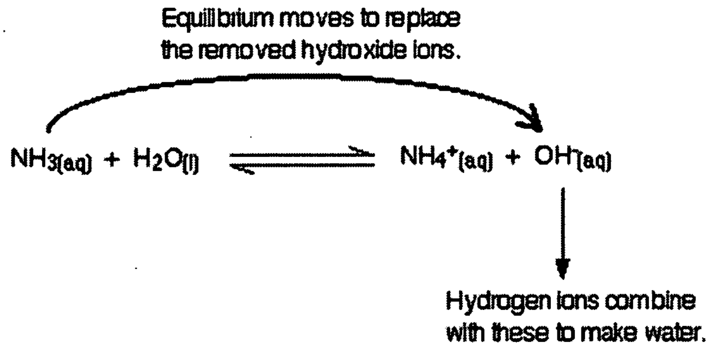
Most, but not all, of the hydrogen ions will be removed. The ammonium ion is weakly acidic, and so some of the hydrogen ions will be released again.

Removal of the hydrogen ions by reacting with hydroxide ions

Remember that there are some hydroxide ions present from the reaction between the ammonia and the water.

$$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)}$$

Hydrogen ions can combine with these hydroxide ions to make water. As soon as this happens, the equilibrium tips to replace the hydroxide ions. This keeps on happening until most of the hydrogen ions are removed.


Equilibrium moves to replace the removed hydroxide ions.
NH3(aq) + H2O(l) ⇌ NH4+(aq) + OH-(aq)
Hydrogen ions combine with these to make water.

Again, because you have equilibria involved, not *all* of the hydrogen ions are removed - just most of them.

Adding an alkali to this buffer solution

The hydroxide ions from the alkali are removed by a simple reaction with ammonium ions.

$$NH_4^+{}_{(aq)} + OH^-_{(aq)} \rightleftharpoons NH_{3(aq)} + H_2O_{(l)}$$

Because the ammonia formed is a weak base, it can react with the water - and so the reaction is slightly reversible. That means that, again, most (but not all) of the the hydroxide ions are removed from the solution.

Where would you like to go now?

To the acid-base equilibria menu . . .

To the Physical Chemistry menu . . .

To Main Menu . . .

Found this page useful? Hate chemistry calculations? You need help!

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buff·er 1 (bŭf′ər)
n.

1. One that buffs, especially a piece of soft leather or cloth used to shine or polish.
2. A buffing wheel.

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buff·er 2 (bŭf′ər)
n.

1. Something that lessens or absorbs the shock of an impact.
2. One that protects by intercepting or moderating adverse pressures or influences: *"A sense of humor . . . may have served as a* **buffer** *against the . . . shocks of disappointment" James Russell Lowell.*
3. Something that separates potentially antagonistic entities, as an area between two rival powers that serves to lessen the danger of conflict.
4. ***Chemistry*** A substance that minimizes change in the acidity of a solution when an acid or base is added to the solution.
5. *Computer Science* A device or area used to store data temporarily.

tr.v. **buff·ered, buff·er·ing, buff·ers**

1. To act as a **buffer** for or between.
2. ***Chemistry*** To treat (a solution) with a **buffer**.
3. *Computer Science* To hold or collect (data) in a **buffer**.

[Probably from obsolete `buff`, *to make a sound like a soft body being hit, of imitative origin.*]

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Thesaurus

Legend: ▌Synonyms ▌Related Words ▌Antonyms

Noun 1. buffer - an ionic compound that resists changes in its pH

▌**buffer** solution - a solution containing a **buffer**

▌chemical compound, compound - (**chemistry**) a substance formed by chemical union of two or more elements or ingredients in definite proportion by weight

2. buffer - an inclined metal frame at the front of a locomotive to clear the track

▌cowcatcher, fender, pilot

▌frame, framing, framework - a structure supporting or containing something

▌locomotive, locomotive engine, railway locomotive, engine - a wheeled vehicle consisting of a self-propelled engine that is used to draw trains along railway tracks

3. buffer - (computer science) a part of RAM used for temporary storage of data that is waiting to be sent to a device; used to compensate for differences in the rate of flow of data between components of a computer system

▌**buffer** storage, **buffer** store

▌memory cache, cache - (computer science) RAM memory that is set aside as a specialized **buffer** storage that is continually updated; used to optimize data transfers between system elements with different characteristics

▌frame **buffer** - (computer science) a **buffer** that stores the contents of an image pixel by pixel

▌keyboard **buffer** - a **buffer** that keeps track of key strokes until the computer is ready to respond to them

▌memory device, storage device - a device that preserves information for retrieval

▌print **buffer** - a **buffer** that stores data until the printer is ready

▌RAM, random access memory, random memory, random-access memory, read/write memory - the most common computer memory which can be used by programs to perform necessary tasks while the computer is on; an integrated circuit memory chip allows information to be stored or accessed in any order and all storage locations are equally accessible

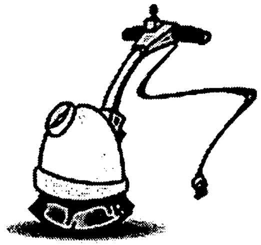
▌computer science, computing - the branch of engineering science that studies (with the aid of computers) computable processes and structures

4. buffer - a power tool used to buff surfaces

▌polisher

▌buffing wheel - a wheel that is covered with soft material

▌power tool - a tool driven by a motor



5. buffer - a cushion-like device that reduces shock due to contact

▌fender

▌auto, automobile, car, motorcar, machine - 4-wheeled motor vehicle; usually propelled by an internal combustion engine; "he needs a car to get to work"

▌device - an instrumentality invented for a particular purpose; "the device is small enough to wear on your wrist"; "a device intended to conserve water"

6. buffer - an implement consisting of soft material mounted on a block; used for polishing (as in manicuring)

▌buff

▌implement - instrumentation (a piece of equipment or tool) used to effect an end

Verb 1. buffer - add a **buffer** (a solution); "buffered saline solution for the eyes"

▌modify - make less severe or harsh or extreme; "please modify this letter to make it more polite"; "he modified his views on same-gender marriage"

2. buffer - protect from impact; "cushion the blow"

▌cushion, soften

▌modify - make less severe or harsh or extreme; "please modify this letter to make it more polite"; "he modified his views on same-gender marriage"

⊟ Mentioned in ?

area of separation laser footprint

⊟ References in classic literature ?

I suppose, waiter,' he said, shaking his shock of hair, as a Newfoundland dog might shake his before sitting down to

buffer solution
buffer state
buffer storage
buffer store
Bufferhead
cache
Dead block
frame **buffer**
keyboard **buffer**
line of demarcation
memory cache
minimum nuclear safe distance
PBS
phosphate **buffer** solution
print **buffer**
random memory
starting **buffer**

More results ▸▸

dinner, 'that a fair lodging for a single **buffer** might be found in these parts, eh?

The Mystery of Edwin Drood by Dickens, Charles **View in context**

The old **buffer** signed it like winking, directly he spotted the rum, but we ain't quite happy about it; you see, it ain't to be supposed that he's got a conscience, and there's only us saw him put his mark there.

A Millionaire of Yesterday by *Oppenheim, E. Phillips* **View in context**

I 've been an extravagant rascal, I know it, and I 'm thundering sorry, but that don't help a fellow, I 've got to tell the dear old **buffer**, and there 's where it cuts.

An Old-Fashioned Girl by *Alcott, Louisa May* **View in context**

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buffalo plaid
buffalo robe
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Buffalo wing
buffalofish
Buffel duck
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buffer state
buffer storage
buffer store
buffer zone

⊟ Full browser [?]

▣ buffaloed
■ buffaloed
● Buffaloes
■ Buffaloes
▣ Buffaloes
■ Buffaloes
● buffalofish
■ buffalofish
■ buffalofish
● buffaloing
■ buffaloing
▣ buffaloing
■ buffaloing
● Buffalonian
● buffalos
■ buffalos
▣ buffalos
■ buffalos
● buffed
■ buffed
■ Buffel
● Buffel duck
● buffel grass
■ Buffelgrass
▸ **buffer**
● **Buffer** & Executive Control
▣ **Buffer (chemistry)**
■ **Buffer (chemistry)**
■ **Buffer** (computer science)
▣ **buffer** (computing)
■ **Buffer** (rail transport)
● **Buffer** Access Card
● **Buffer** Address Register
● **Buffer** Allocation Map
● **Buffer** Allocation Size
● **Buffer** amplifier
● **Buffer** amplifier
■ **Buffer** amplifier
● **Buffer** Area List Entry
● **Buffer** Broadcasting
● **Buffer** Cache Hit Ratio (Oracle databases)
● **Buffer** Compare Status
● **Buffer** Control Block
● **Buffer** Control Element
● **Buffer** Control Unit
● **Buffer** Control Word
● **Buffer** Controller (Sprint)
● **buffer** country
■ **buffer** country

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Buffer solution

From Wikipedia, the free encyclopedia
(Redirected from Buffer (chemistry))

Buffer solutions are solutions which resist change in hydronium ion concentration (and consequent pH) upon addition of small amounts of acid or base, or upon dilution. Buffer solutions consist of a weak acid and its conjugate base. The resistive action is the result of the equilibrium between the weak acid (HA) and its conjugate base (A^-):

$$HA(aq) + H_2O(l) \square H_3O^+(aq) + A^-(aq)$$

Any alkali added to the **solution** is consumed by hydronium ions. These ions are mostly regenerated as the equilibrium moves to the right and some of the acid dissociates into hydronium ions and the conjugate base. If a strong acid is added, the conjugate base is protonated, and the pH is almost entirely restored. This is an example of Le Chatelier's principle and the common ion effect. This contrasts with solutions of strong acids or strong bases, where any additional strong acid or base can greatly change the pH.

Acids and bases:

Acid-base reaction theories
pH
Self-ionization of water
Buffer solutions
Systematic naming
Electrochemistry
Acids:

- Strong acids
- Weak acids

Bases:

- Strong bases
- Weak bases

When writing about buffer systems they can be represented as salt of conjugate base/acid, or base/salt of conjugate acid. It should be noted that here buffer solutions are presented in terms of the Brønsted-Lowry notion of acids and bases, as opposed to the Lewis acid-base theory (see acid-base reaction theories). Omitted here are buffer solutions prepared with solvents other than water.

Contents

- 1 Calculating pH of a buffer
- 2 Illustration of **Buffering** Effect: Sodium acetate/Acetic acid
- 3 Applications
- 4 Common Buffer Compounds used in Biology
- 5 Making buffer solutions
  - 5.1 Citric acid-phosphate buffer
- 6 See also
- 7 External links

Calculating pH of a buffer

The equilibrium above has the following acid dissociation constant:

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

Simple manipulation with logarithms gives the Henderson-Hasselbalch equation, which describe pH in terms of pK_a:

$$pH = pK_a + log_{10}\frac{[A^-]}{[HA]}$$

In this equation

1. [A-] is the concentration of the conjugate base. This may be considered as coming completely from the salt, since the acid supplies relatively few anions compared to the salt.
2. [HA] is the concentration of the acid. It again is minimally dissociated, and hence can be considered a constant.

Illustration of Buffering Effect: Sodium acetate/Acetic acid

The acid dissociation constant for acetic acid-sodium acetate is given by the equation:

$$K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$$

Since this equilibrium only involves a weak acid and base, it can be assumed that ionization of the acetic acid and hydrolysis of the acetate ions are negligible. In a buffer consisting of equal amounts of acetic acid and sodium acetate, the equilibrium equation simplifies to

$K_a = [H^+]$,

and the pH of the buffer as is equal to the pK_a.

To determine the effect of addition of a strong acid such as HCl, the following mathematics would provide the new pH. Since HCl is (a strong acid) it is completely ionized in **solution**, and increases the concentration of H^+ in **solution**, which then neutralizes the acetate by the following equation.

$$CH_3COO^-_{(aq)} + H^+_{(aq)} \rightarrow CH_3COOH_{(aq)}$$

The consumed hydrogen ions change the effective number of moles of acetic acid and acetate ions:

$$\text{moles of } CH_3COO^- = \text{initial moles of } CH_3COO^- - \text{initial moles of HCl}$$
$$\text{moles of } CH_3COOH = \text{initial moles of } CH_3COOH + \text{initial moles of HCl}$$

After accounting for volume change to give concentrations, the new pH could be calculated from the Henderson-Hasselbalch equation. Any neutralization will result in a small change in pH since it is on a logarithmic scale.

Applications

Their resistance to changes in pH makes buffer solutions very useful for chemical manufacturing and essential for many biochemical processes. The ideal buffer for a particular pH has a pK_a equal to the pH desired, since a **solution** of this buffer would contain equal amounts of acid and base, and be in the middle of the range of **buffering** capacity.

Buffer solutions are necessary to keep the right pH for enzymes in many organisms to work. A lot of enzymes work only under very precise conditions, if the pH strays too far out of the margin the enzymes slow or stop working and the enzyme can denature, thus permanently disabling its catalytic activity. A buffer of carbonic acid (H_2CO_3) and bicarbonate (HCO_3^-) is present in blood plasma, to maintain a pH between 7.35 and 7.45.

Industrially buffer solutions are useful in fermentation processes, and for setting the correct conditions for the dyes used in colouring fabrics.

Also, buffer **solution** can be used in chemical analysis and calibration of pH meters.

Common Buffer Compounds used in Biology

Common Name	**pK_a at 25° C**	**Buffer Range**	**Temp Effect (pH / °C) ****	**Mol. Weight**	**Full Compound Name**
TAPS	8.43	7.7 - 9.1	-0.018	243.3	3-{[tris(hydroxymethyl)methyl]amino} propanesulfonic acid
Bicine	8.35	7.6 - 9.0	-0.018	163.2	N,N-bis(2-hydroxyethyl)glycine
Tris	8.06	7.5 - 9.0	-0.028	121.14	tris(hydroxymethyl)methylamine
Tricine	8.05	7.4 - 8.8	-0.021	179.2	N-tris(hydroxymethyl)methylglycine
HEPES	7.48	6.8 - 8.2	-0.014	238.3	4-2-hydroxyethyl-1-piperazineethanesulfonic acid
TES	7.40	6.8 - 8.2	-0.020	229.20	2-{[tris(hydroxymethyl)methyl]amino}ethanesulfonic acid
MOPS	7.20	6.5 - 7.9	-0.015	209.3	3-(N-morpholino)propanesulfonic acid
PIPES	6.76	6.1 - 7.5	-0.008	302.4	piperazine-N,N′ -bis(2-ethanesulfonic acid)
Cacodylate	6.27	5.0 - 7.4		138.0	dimethyl arsenate
MES	6.15	6.1 - 7.5	-0.011	195.2	2-(N-morpholino)ethanesulfonic acid
Acetate	4.76	3.8 - 5.8		59.04	—

** Values are approximate

More Buffers (http://www.sigmaaldrich.com/Area_of_Interest/Laboratory_Essentials/BioBasics/Key_Resources/Technical_Library.html) at Sigma-Aldrich

Making buffer solutions

Citric acid-phosphate buffer

Make up 0.1M citric acid and 0.2M phosphate solutions then mix as follows,

Citric acid-phosphate buffers

pH	**0.2M Na_2HPO_4 /ml**	**0.1M Citric Acid /ml**
3.0	20.55	79.45

4.0	38.55	61.45
5.0	51.50	48.50
6.0	63.15	36.85
7.0	82.35	17.65
8.0	97.25	2.75

See also

- **Buffering** agent
- common ion effect

External links

- Example buffer recipes (http://apps3.fao.org/jecfa/additive_specs/docs/t0368e/t0368e14.htm)
- Derivation and discussion of Henderson-Hasselbalch equation (http://www.chembuddy.com/?left=pH-calculation&right=pH-buffers-henderson-hasselbalch)

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